



Maximum Sustainable Yield Estimates of *Scomberomorus* spp. from Balochistan, Pakistan

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ABSTRACT

Pakistani fisheries resources are influenced by habitat destruction, pollution and over-exploitation. Therefore, it is necessary to evaluate fisheries resources prior to harvest. In this study, two specialized fishery software's viz. CEDA (catch and effort data analysis) and ASPIC (a stock production model incorporating covariates) are used to analyze the fishery output (FO) and fishery input (FI) data of *Scomberomorus* spp. to evaluate their fishery stock status in Pakistani marine waters from Balochistan coastline. Three surplus production models (SPMs) viz. Fox (F-M), Schaefer (S-M) and Pella-Tomlinson (PT-M) along with three error assumptions (EAs), log (L-EA), log normal (LN-EA) and gamma (G-EA), were used in CEDA while two SPMs, Fox (F-M) and logistic (L-M) were used in ASPIC. In CEDA, for initial proportion (IP) 0.9, F-M for L-EA and LN-EA estimated maximum sustainable yield (MSY) as 2593 t and 2282 t. However, G-EA produced minimization failure (MF). Estimated MSY for L-EA and LN-EA through S-M and PT-M were remained same viz. 3523 t and 4584 t, respectively. However, here G-EA assumption also showed MF. In ASPIC, for same IP, F-M and L-M estimated MSY as 2313 t and 5191 t. Overall, F-M results, in ASPIC, reveal highest goodness of fit R^2 (0.937) values. The FO statistics reveal that this stocks is over-fished. Thus, it requires some proficient management and immediate steps to conserve this fishery resource for future generations.

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Authors' Contribution

MN initiated the project, procured and analyzed the data. YTM designed and supervised the study. MM compiled the results. AMM and MTK helped in writing of the article.

Key words

Seer fishes, Stock assessment, Surplus production models, Pakistan.

INTRODUCTION

Family Scombridae includes mackerels, tunas, bonitos, and some of the world's most prevalent food fishes. The fishes belonging to this family are also considered as the fastest-swimming fishes in the world (Orrell *et al.*, 2006). Some, particularly the smaller mackerels, live in shallow water near the coast, while many others wander deeper waters, often in wide migratory patterns. Mackerels are predators and forage crabs, shrimps, squids, crustaceans, egg and larvae of fishes and invertebrates, and small fishes. They are, in turn, provide food for each other, large fishes, porpoises, seals and sea birds. They spawn in the spring and early summer along the coast in shallow water (Wheeler, 1985; Helfman *et al.*, 1997; Johnson and Gill, 1998).

The term seer fish is used here for the following commercially important fish species belongs to subfamily of the Scombridae or Mackerel family: *Scomberomorus guttatus*, *S. commerson*, *S. lineotatus* and *S. koreanus*. They are also popular game fish, growing up to 45 kg, and is a strong fighter that has on occasion been seen to leap

out of the water when hooked. It is an excellent table fish. *Scomberomorus* spp. are primarily caught by troll lines, hook and lines, long lines, drift gillnets and purse seines (Sinha *et al.*, 2015).

The SPMs are also known as biomass dynamic models. Currently, numerous studies on SPMs have been done for stock assessment of fishery resources. These SPMs compute all the effects of growth, mortality and recruitment into a single production function. Hence, they become more preferable models in stock assessment studies. SPMs also own basic importance in tropical fisheries where age determination is relatively difficult or impossible (Haddon, 2011) because the bends on otoliths for age determination are difficult to examine due to changing weather. However, SPMs need use FO and FI data or index of abundance (catch per unite effort-CPUE). Their predictable factors can simply be recorded on the basis of biological reference point or MSY in order to device harvest policies for sustainable fishing (Jensen, 2002).

SPMs based on the concept of fishery stock depletion which means the drop in abundance indicator due to withdrawal of fishery stock. Depletion models require continuous FI data without gaps because data gaps can be the cause of wrong assessment. These models may also require good index of relative population size in

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comparison of actual population size. In addition, catch per unit effort (CPUE) can also be a determining factor to evaluate different parameters in place of FI statistics. So, the fish stock can be accessed by FI statistics or CPUE (Hoggarth *et al.*, 2006). A lot of published literature point out that SPMs are very imperative tools in fishery stock assessment and have been used worldwide in fishery management (Ricker, 1975; Pitcher and Hart, 1982; Hilborn and Walters, 1992; Prager, 1994, 2005; Quinn and Deriso, 1999; Maunder *et al.*, 2006; Panhwar *et al.*, 2012). Currently, various software have been developed which have the ability to estimate biomass dynamics of the exploited fishery stock *e.g.* ASPIC and CEDA. These computer packages are easily assessable and very useful time saving tools.

Maximum sustainable yield (MSY) and maximum economic yield (MEY) are the two reference points which are used to manage fishery resources around the world. Though, according to economists the concept of MSY sounds great (Gordon, 1954; Grafton *et al.*, 2007) however the benefits of this reference point are not witnessed till now. It has been found that MSY reference point is the better reference point at which maximum economic utility of the fishery resources is generated (Christensen, 2010).

Scomberomorus spp., locally known as “surmai”, are landed throughout coast of Pakistan but their production is considerably high along Balochistan coastline. They are considered one of the valuable food fishes throughout the country. Moreover, they have great economic importance because of their good demand in other countries. Despite commercial important of sear fishes no published literature is available on the stock assessment of this fishery stock from Pakistani marine waters. This research article is the first reporting about the fishery stock of *Scomberomorus* spp. by using FO and FI statistics.

MATERIALS AND METHODS

Data procurement

The fishery status of *Scomberomorus* spp. was evaluated by using available FO and FI data for this fishery resource from marine waters of Pakistan.

Data analysis

The SPMs was used in this study to statistically analyze the collected time series data of 18 years period (1997-2014) of *Scomberomorus* spp. The specialized tools *i.e.* CEDA and ASPIC of SPMs used for analyzing data were downloaded from MRAG website and NOAA Fisheries Toolbox, correspondingly. These stock assessment tools ponder fishery stock to be in non-equilibrium state and were employ all together here to eliminate uncertainties

and develop more confidence in the results. The CPUE was used as nominal in this study by keeping in view the description of Hoggarth *et al.* (2006) on the subject of the use of CPUE in fish stock assessment.

SPMs are also known as biomass dynamic models based on various assumptions which have three different versions on the behalf of three different scientists Fox, Schaefer and Pella-Tomlinson. Schaefer is most frequently used model and rely on a logistic population growth model (Schaefer, 1954).

$$\frac{dB}{dt} = rB(B_{\infty} - B)$$

On the other hand, Fox and Pella-Tomlinson model are based on Gompers growth equation (Fox, 1970) and generalized production equation (Pella and Tomlinson, 1969), respectively.

$$\frac{dB}{dt} = rB(\ln B_{\infty} - \ln B)$$

$$\frac{dB}{dt} = rB(B_{\infty}^{n-1} - B^{n-1})$$

Where, B stands for fish stock biomass, n is shape parameter, t represents for the time (year), B_{∞} is carrying capacity (K) and r denotes the intrinsic rate of population growth.

CEDA (version 3.0.1)

CEDA (catch and effort data analysis) computer package is menu driven data fitting tool and has the aptitude to approximate customized parameters. CEDA uses a confidence interval of 95% through bootstrapping method for all the SPMs models *i.e.* F-M, S-M and PT-M with three *viz.* L-EA, LN-EA and G-EA. It needs an input of IP (B_1/K) which is a key indicator used to access fishery stock. For example, if the input value of IP is zero or close to zero then its mean that data is obtained from virgin fishery stock. Similarly, if the input value is one then it does assume that data is acquired from fully developed fishery stock. Sometimes, initial biomass is fixed as $B_1 = C_1/(qE_1)$. In this mathematical statement, C is catch (FO); q and E denote effort (FI) and catchability coefficient correspondingly. Some programmers also use B_1 equal to K (carrying capacity). CV (coefficient of variation) is predicted by using confidence intervals. Other key parameters expected by using CEDA are MEY, K , q , r (intrinsic growth rate), R yield (replacement yield) and final biomass.

ASPIC (Version 5.0)

ASPIC (a stock production model incorporating covariates) software also requires an input of IP. However, in contrast to CEDA, it needs individual input files for each IP value. Two SPMs *i.e.* F-M (a special case of GENFIT)

and L-M (also called Schaefer model) were employed by using this fishery software. FIT and BOT files, for both of the SPMs, were prepared to calculate CV for all IP values. FIT and BOT represent the program modes used in ASPIC and exists a technical difference between them. The managerial parameters are computed by ASPIC software during FIT mode while during BOT program mode it uses bootstrapped CIs with many trials for the calculation of parameters. Therefore, the finishing time of BOT mode is much higher than FIT mode. 500 trails were done in order to compute MEY. Different Important parameters approximated by using this computer package include MEY, K , q , $B1/K$ (starting biomass over carrying capacity), R^2 (coefficient of determination), F_{MSY} (fishing mortality rate at MSY), B_{MSY} (stock biomass giving MSY).

Sensitivity analysis was performed for constant recruitment model. However, due to unpredictable results derived we switched to non-equilibrium SPMs evaluation *i.e.* three production models. Within these models again sensitivity analysis was performed by using IP values (Tables II and V). The results obtained for different parameters were further considered along with R^2 values and visual inspection of the graphs for model selection and evaluation for representing reliable results.

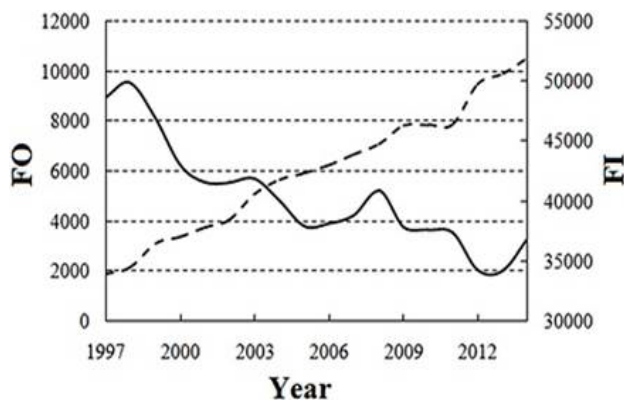


Fig. 1. FI and FO statistics of *Scomberomorus* spp. from Balochistan, Pakistan. Note. FI (dotted line) is represented by the number of fishermen whereas FO (solid line) is in t.

RESULT

The total capture production of *Scomberomorus* spp. stated during the study period from Pakistani marine water was 90056 t. Figure 1 reveals that maximum and minimum quantity of FO examined was 9567 t (1998) and 2031 t (2013) while the average FO remained 5003 t year⁻¹. The average CPUE during the study period remained 0.125 year⁻¹. Highest and lowest values of CPUE were observed during the second and seventeenth study year *i.e.* 1998

(0.278) and 2013 (0.040) in that order (Fig. 2). The results obtained by computation through CEDA and ASPIC were further evaluated in term of four factors: MSY; R^2 ; residual plots between observed and expected FOs; and CV. Estimated MSY values were compared with data figures and very large or small MSY values were neglected. Models were compared on the basis of R^2 values and visual examination of residual plots. The higher is the value of R^2 the better is the fitting of the model and vice versa. Results with suitable CV values were acknowledged.

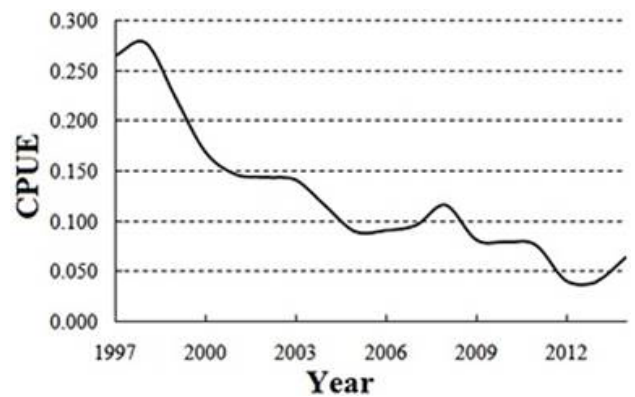


Fig. 2. Computed CPUE for *Scomberomorus* spp. from Balochistan, Pakistan.

CEDA Estimates

For CEDA, the results for various parameters for IP 0.9 are given in Table I. Computed values of MSY and their CV for F-M with N-EA and LN-EA were 2593 t, 0.161 and 2282 t and 0.263, respectively. However, G-EA showed MF for F-M. Computed MSY values for L-EA and LN-EA used in S-M and PT-M remained same while G-EA here also showed MF. For both *viz.* S-M and PT-M, computed MSY values for L-EA and LN-EA were 3523 t and 4584 t correspondingly. Similarly, estimated CV were 0.196, 0.018 and 0.174, 0.015 in that order. Estimated B_{MSY} values are identical for the entire S-M and PT-M. This may be due to the convergence of PT-M at 0.5 of B_{MSY}/K which suggests the results of this model may not be significant. However, for model evaluation full criteria used has already been discussed.

CEDA revealed sensitivity towards the input IP values as it produced different output MSY estimates for different IP inputs (Table III). Sometimes N-EA and G-EA showed MF in all the SPMs used. Moreover, for both S-M and PT-M, N-EA produced MF for IP values of 0.2 and 0.4. CV values were obtained by using a special method called bootstrapping confidence limit method. For all the SPMs used along with their EAs either MSY or R^2 value did not produce rational results except for IP

0.9. For IP 0.9, values of R^2 by using N-EA and LN-EA in F-M were 0.890 and 0.826, respectively. For both *i.e.* S-M and PT-M, R^2 values were same as 0.887 and 0.835 correspondingly. R^2 (the goodness of fit) values are very important to consider as they tell us about the fitting of the model. Figure 3 shows the graphical representation of observed and expected annual FO values. From visual inspection it can be expected that observed and expected FO values are considerably close to each other for all the EAs used in F-M, however in detail, they differ from each other. The results of CEDA illustrate higher MSY values with lower IP values and vice versa.

ASPIC estimates

ASPIC computer software did not produce results for IP 0.1 – 0.3 because the data set did not suite to all IP values. It computed various parameters for only IP values 0.4 – 0.9 which results are presented in Table IV. Like CEDA, ASPIC also showed sensitivity to IP values as it computed different output parameter values for different IP input. ASPIC estimated larger MSY for smaller IP value and vice versa. However, parameters computed by this software did not show higher variation as compared to CEDA. For instance, computed MSY by ASPIC ranged in 2300 t - 8000 t while for CEDA its estimated range was 2000 t - 70000 t.

Table I.- CEDA estimates of various parameters for *Scomberomus* spp. from Balochistan, Pakistan (IP = 0.9).

Model	R^2	MSY	CV	K	q	r	R_{yield}	B
FM-LEA	0.89	2593	0.161345	67308	0.00000506	0.014729	2034	10400
FM-LNEA	0.826	2282	0.262927	73280	0.00000448	8.47E-02	1755	10860
FM-GEA	MF	MF	MF	MF	MF	MF	MF	MF
SM-LEA	0.887	3523	0.195653	53290	0.00000652	0.264445	1634	7132
SM-LNEA	0.835	4584	0.018365	37400	0.0000105	0.490264	1883	4346
SM-GEA	MF	MF	MF	MF	MF	MF	MF	MF
PTM-LEA	0.887	3523	0.173785	53290	0.00000652	0.264445	1634	7132
PTM-LNEA	0.835	4584	0.014692	37400	0.0000105	0.490264	1883	4346
PTM-GEA	MF	MF	MF	MF	MF	MF	MF	MF

MSY, maximum sustainable yield; CV, coefficient of variation; R2, coefficient of determination; K, carrying capacity; q, catchability coefficient; r, intrinsic population growth rate; RYield, replacement yield; B, current biomass; MF, minimization failure

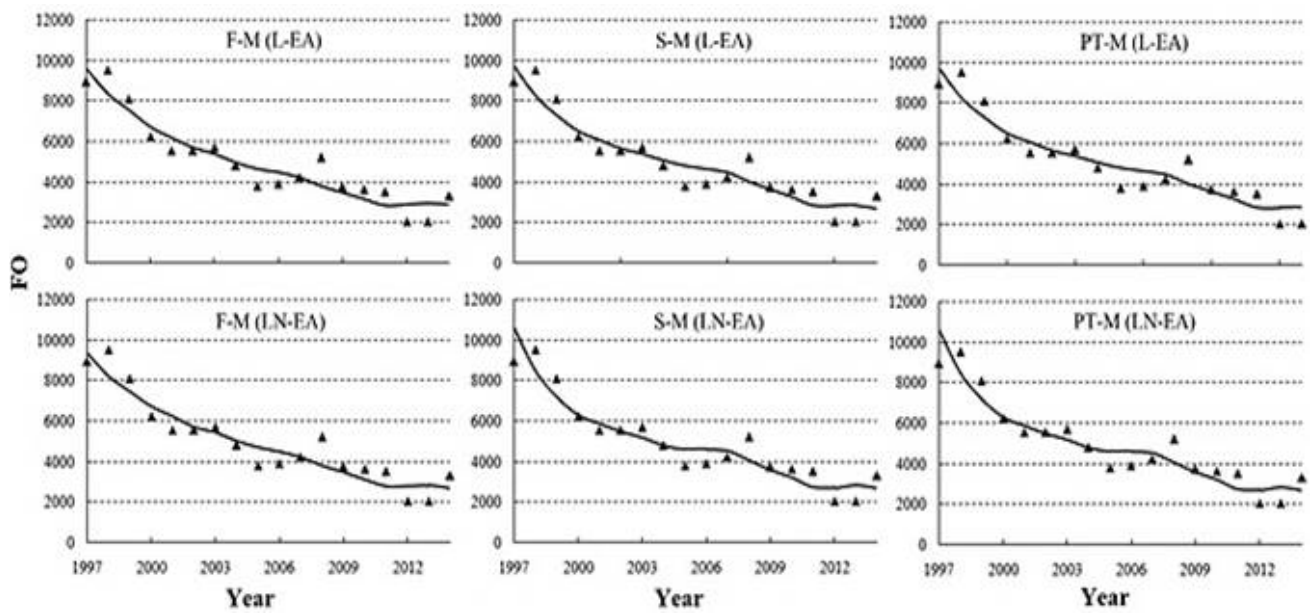


Fig. 3. Graphs obtained by using CEDA software for IP 0.9.

Table II.- CEDA estimates of various parameters for *Scomberomorus* spp. from Balochistan, Pakistan (IP = 0.1-0.9).

IP	Model								
	Fox			Schaefer			Pella Tomlinson		
	N-EA	LN-EA	G-EA	N-EA	LN-EA	G-EA	N-EA	LN-EA	G-EA
0.1	MF	9923	MF	69864	4425	21512	69864	9819	21512
	0	0.000668	0	0.042656	0.025597	0.0000712	0.0426265	0.17833	9.49E-05
0.2	34775	6088	MF	MF	11603	MF	MF	6088	MF
	0.409498	0.017599	0	0	8.79E-05	0	0	0.011733	0
0.3	5779	4657	16809	35002	8392	32848	35002	8392	32848
	0.057209	0.051163	0.013477	0.005291	0.000182	0.17334	0.0053058	0.000182	0.169752
0.4	4637	3880	MF	MF	6838	MF	MF	6838	MF
	0.107278	0.092047	0	0	0.000224	0	0	0.000224	0
0.5	3925	2884	MF	MF	5950	5946	MF	5950	5946
	0.119199	0.218659	0	0	0.000257	0.000343	0	0.000257	0.000343
0.6	3437	2770	29467	5747	5371	MF	5747	5371	MF
	0.139686	0.191004	0.016639	0.029119	0.002185	0	0.0284976	0.00228	0
0.7	3080	2747	MF	4781	5053	31555	4781	5053	31555
	0.13865	0.209134	0	0.092949	0.006563	0.339446	0.092842	0.006765	0.171388
0.8	2078	2224	18511	4071	4663	MF	4071	4663	MF
	0.396034	0.311766	0.01017	0.154904	0.010942	0	0.152773	0.012145	0
0.9	2593	2282	MF	3523	4584	MF	3523	4584	MF
	0.170002	0.281931	0	0.192901	0.017808	0	0.1986943	0.015693	0

CV, coefficient of variation is written below MSY values; MF, represents minimization failure.

Table III.- ASPIC estimates of various parameters for *Scomberomorus* spp. from Balochistan, Pakistan (IP = 0.9).

Model	IP	MSY	CV	R ²	B _{MSY}	F _{MSY}	K	q
F-M	0.9	2313	0.23469829	0.937	26430	0.08749	71850	0.00004546
L-M	0.9	5191	0.07134072	0.911	14020	0.3703	28030	0.00001462

Table IV.- ASPIC estimates for *Scomberomorus* spp. from Balochistan, Pakistan (IP = 0.3-0.9).

Model	IP	MSY	CV	R ²	K	B _{MSY}	F _{MSY}	q
F-M	0.4	4947	0.08674366	0.937	4947	27100	0.1826	0.00001081
	0.5	3901	0.13282027	0.938	79320	29180	0.1337	0.00007699
	0.6	3276	0.17258383	0.937	79110	29100	0.1126	0.00006315
	0.7	2866	0.19363051	0.937	76760	28240	0.1015	0.00005531
	0.8	2557	0.2355095	0.937	74250	27310	0.0936	0.00004974
	0.9	2313	0.23469829	0.937	71850	26430	0.0875	0.00004546
L-M	0.4	7913	0.02485825	0.915	37770	18890	0.419	0.00001854
	0.5	7054	0.01892777	0.926	31230	15620	0.4517	0.0000193
	0.6	6672	0.12986863	0.926	25590	12790	0.5215	0.00002137
	0.7	6247	0.0255947	0.919	24240	12120	0.5155	0.00002063
	0.8	5752	0.03572575	0.912	25270	12630	0.4553	0.00001805
	0.9	5191	0.07134072	0.911	28030	14020	0.3703	0.00001462

Table V.- ASPIC software estimates of fishing mortality (F) and biomass (B) (IP = 0.9) (1997-2014).

Year	Model							
	F-M				L-M			
	F	B	F/F _{MSY}	B/B _{MSY}	F	B	F/F _{MSY}	B/B _{MSY}
1997	0.149	64660	1.698	2.446	0.407	25240	1.099	1.8
1998	0.183	56580	2.089	2.141	0.561	19670	1.515	1.403
1999	0.179	48450	2.051	1.833	0.606	15000	1.635	1.070
2000	0.156	42160	1.785	1.595	0.548	12050	1.481	0.860
2001	0.154	37960	1.757	1.436	0.534	10810	1.441	0.771
2002	0.169	34560	1.931	1.308	0.576	10090	1.556	0.720
2003	0.194	31260	2.212	1.183	0.67	9223	1.809	0.658
2004	0.181	27840	2.072	1.053	0.641	7901	1.73	0.564
2005	0.155	25340	1.767	0.959	0.524	7159	1.415	0.510
2006	0.170	23850	1.938	0.902	0.527	7339	1.423	0.524
2007	0.199	22230	2.279	0.841	0.575	7471	1.553	0.533
2008	0.279	20270	3.187	0.767	0.811	7257	2.19	0.518
2009	0.230	17260	2.624	0.653	0.693	5707	1.872	0.407
2010	0.248	15610	2.832	0.591	0.761	5183	2.055	0.367
2011	0.268	14000	3.069	0.530	0.903	4472	2.439	0.319
2012	0.166	12410	1.894	0.470	0.576	3426	1.554	0.244
2013	0.166	12270	1.903	0.464	0.52	3678	1.404	0.262
2014	0.292	12130	3.34	0.460	0.921	4136	2.486	0.295

F, fishing mortality; B, biomass; F/F_{MSY}, ratio of fishing mortality to fishing mortality rate at MSY; B/B_{MSY}, ratio of biomass to biomass giving MSY.

It means although ASPIC is sensitive to IP values but its sensitivity is less than CEDA. ASPIC models in contrast to CEDA revealed higher R^2 values demonstrating better fitting of the data. The results of different calculated parameters for IP 0.9 are listed in Table III. MSY along with their CV values for the SPMs, F-M and L-M used in ASPIC, were estimated at 2313 t (0.235) and 5191 t (0.071), respectively. F-M presented better fit as its R^2 value (0.039) was higher than the computed R^2 value (0.911) for L-M. For F-M and L-M, computed B_{MSY} , F_{MSY} and K remained 26430 t, 0.087 t, 71850 t and 14020, 0.037 t, 28030 t for in that order.

Estimated fishing mortality (F) and biomass (B) values of *Scomberomorus* spp. by using ASPIC are listed in Table V. Computed estimates highlight that F has shown rising trend with the passage of time whereas B is declining. F/F_{MSY} is increased and B/B_{MSY} is decreased during the course of study period. Both, F/F_{MSY} and B/B_{MSY} is a sign of overexploitation of the fishery stock.

DISCUSSION

The findings of current study show that *Scomberomorus* spp. are overexploited in Pakistani marine waters. This overexploitation of fishery resources may

lead to various draw backs to the society. For instance, competitive harvesting of the fishery resources is the result of this overharvesting. Likewise, private stakeholders, without considering the damage caused by overfishing, also attempt to maximize their profits. Furthermore, fishery stock may led to the depletion state because of substantial increase in FO in order to get maximum profit. Thus, it becomes very necessary to access the commercial fishery stock on regular basis to make sure sustainable economic contribution of fishery resources (Clark, 1973).

As described earlier, overexploitation may lead to fishery stock depletion. This depletion is actually the result of an attempt to uplift profit gain beyond the capacity of the fishery stock (Clark, 1973). In the beginning of fishery, fishermen get more profit with lower FI. At this stage, the spurs generated by fishery, fascinates more and more fishermen to join fishery however a stage approaches when profit goes negative. At this stage, for more FI lesser FO is obtained and B_{CUR} becomes lower than B_{MSY} . Consequently, fishing does not remain economic. Hence, fishery stock building is usually recommended in order to make fishing beneficial again.

The ideas of fishery stock rebuilding sounds great but practically it confers many problems. These problems are associated with the willingness of fishers to comply with

the idea of fishery stock rebuilding. These reasons for this opposition are the difference in the growth rate of the fishes. Obviously, fast growing fishes will rebuild quickly where for slow growing fish species it will take so long time, even decades (Grafton *et al.*, 2007). Another drawback of fishery stock rebuilding for fishers is that during the time of fishers have to pay for the transition cost. Thus, in order to agree fishers for rebuilding these transition costs may be supplemented by attractive incentives such as permission of harvesting rights (Hilborn, 2007). These incentives may prove very effective tool to motivate fishers for rebuilding (Grafton, 1995).

Fishery management is principally an integrated process which employs data collection, analysis, explanation of results, consultation, planning and decision making (FAO, 1997) involving stakeholders (Die, 2002). In this study, famous fishery SPMs are used which have already been used for the assessment of stock status of fishery resources in Pakistan (Memon *et al.*, 2015; Siyal *et al.*, 2013; Kalhoro *et al.*, 2013; Panhwar *et al.*, 2012; Kalhoro *et al.*, 2014; Panhwar and Liu, 2013; Kalhoro *et al.*, 2018). Actually, these SPMs possess many advantages over the other routine used in the science of fishery management. Because, the various assumptions of classic SPMs *i.e.* Fox and Schaefer assume that fishery stock is in equilibrium state which is rarely true in nature (Liu and Su, 1998). However, the recent use of CEDA is valuable and provides more suitable and trustworthy estimations as this suppose fishery stock in non-equilibrium state which exists in nature. Hence, in contrast to classical computation of MSY, these non-equilibrium SPMs have implausible elasticity and are reliable tools for fishery management advice (Hoggarth *et al.*, 2006; Medley and Ninnes, 1997).

These models use simple data related to FI and FO. In addition to this, these models estimated simultaneously exclusive parameters of the fishery stock. Besides, computed parameter such as q indicates the fishery stock status. Other main computed fishery parameters include F_{MSY} , B and B_{MSY} . It is necessary to mention that these SPMs rely on some assumption which may not be met in nature. These assumptions include non-existence of immigration or emigration in the fishery stock, age composition of the fishery stock has no relation with r , q does not change with the passage of time, there exists single fishery stock and natural with fishing mortality occur at the same time (Ewald and Wang, 2010; Hoggarth *et al.*, 2006). Moreover, these models does not use data related to age structure of the population and confer the risk of uncertainty in their estimation. Nevertheless, these models are frequently used in the science of fishery management and are very effective tools which tell us about the status of the fishery stock upon which fishery management advice is made

(Musick and Bonfil, 2005).

As this study finds that *Scomberomorus* spp. are overexploited in Pakistani marine waters. Usually, overcapacity is blamed for overexploitation of marine fishery resources. Unfortunately, in Pakistan there exists no proper legislation and its implementation related to the fishery resource utilization. In 2007, first ever national policy related to fisheries was formulated (GoP, 2007). This policy, with many other aims, intended to control FO and FI in order to manage fisheries. However, practically predicted results of this policy regarding FO and FI are not witnessed. A study finds that in Sindh, the number of trawlers used for fishing is more than double as compared to recommended ones (Schmidt, 2014) which indicates that there is found no real existence of fishery management policies.

CONCLUSION

Computed MSY values for IP 0.9, ranged as 2000 t – 70000 t and 2300 t – 8000 for CEDA and ASPIC, respectively. Thus, it means although ASPIC is sensitive to IP values but its sensitivity is less than CEDA and CEDA in terms of computed MSY seems to be more conventional. Higher values of R^2 for ASPIC point to that its results are more reliable. Since the computed MSY range by F-M and L-M overlaps thus by considering the results of both the software and applying pulse fishing rule we recommend that the MSY, TRP range of *Scomberomorus* spp. is as 2300 t – 5100 t in Pakistani marine waters. Capture production of 5500 t or more must be considered as a LRP. By comparing computed MSY values with recorded data (Fig. 1) and considering F/F_{MSY} and B/B_{MSY} it can be concluded that *Scomberomorus* spp. stock has constantly been overexploited earlier. *Scomberomorus* spp. stock is declining with the passage of time due to overfishing. Consequently, instant steps with proper forecast with legal execution are surely needed to conserve this fishery resource for future.

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Statement of conflict of interest

We declare that we have no conflict of interest.

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