Determining the stock status of snapper (Lutjanus sp.) using surplus production model: a case study in Banyuasin coastal waters, South Sumatra, Indonesia

by Fauziyah Fauziyah

Determining the stock status of snapper (*Lutjanus* sp.) using surplus production model: a case study in Banyuasin Coastal Waters, South Sumatra, Indonesia

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Abstract. Snapper (*Lutjanus* sp.) is an economically important fish for local fishermen in Banyuasin coastal water of South Sumatra. However, the current and historical stock of this species is still unknown. The aim of this study was to estimate the stock status of *Lutjanus* sp. in the Banyuasin Coastal Waters. The annual catch and effort data were analyzed from 2008 to 2016 year. The different surplus production models were tested to obtain the best-fitted model based on the sign suitability test, model performance test, and multiple criteria analysis. The results indicated that the best-fitted model for *Lutjanus* sp. was the Fox model. The model had the best value for the determination coefficient (R^2 = 97.2%), Nash-Sutcliffe Efficiency (NSE = -0.277), Mean Absolute Deviation (MAD = 29.198), Mean Square Error (MSE =1,190.522), Root Mean Square Error (RMSE = 34.504), and RMSE-observations Standard Deviation Ratio (RSR = 1.13), whereas the value of Mean Absolute Percentage Error (MAPE = 0.05) was the second-best value. The optimum effort (E_{opt}), maximum sustainable catch (C_{MSY}), and Total Allowable Catch (TAC) were 22.236 trips/year, 623 ton and 498 ton/year, respectively. Based on plotting the effort and exploitation level (141%; 102%) in 2016, the stock status of *Lutjanus* sp. indicated depleting stock. This stock status indicated the high fishing pressure and these conditions could encourage overfishing stock in the future when the exploitation and effort level could not be controlled by the fisheries manager.

Keywords: snapper, stock status, surplus production model

1. Introduction

Banyuasin coastal waters owned a high potential of fish resources and high diversity (Fauziyah et al 2019, Fauziyah et al 2018a). One of the economically important fish in these waters is snapper (*Lutjanus* sp.). Their distribution areas include coastal waters and coral reefs throughout Indonesia, the Bengal Gulf, the Siam Gulf, the South China Sea, Philippines, Australia and South Africa (Ganisa 1999). These species were caught with various types of fishing gear such as gillnet, hooks and line, traps, trawl, and seine net (Ganisa 1999, Noija et al 2014). This condition indicated the dynamics stock for *Lutjanus* sp. due to the fishing pressure. These fishing pressures should be limited to keep the fish stock sustainability in the future.

At present, data and information on *Lutjanus* sp. in the Banyuasin Coastal Waters especially related to effort level, exploitation level, and stock status are not yet available due to the stock assessment for this species has not been conducted. While the data available in the capture fisheries statistics of Banyuasin Regency are only the fish landed and fishing effort data. The statistical data on capture fisheries during 2008-2016 showed that the trend of fishing effort increased every year. Furthermore, the fishing activities in these waters are still of open access. This condition encourages everyone to utilize these resources indefinitely (Patria et al 2014) and tend to be irresponsible to keep the sustainability of the resources (Nurhayati 2013). Increasing fishing capacity results in increasing fishing pressures on fish stocks and eventually leads to over-exploitation as well as depletion of available fish stocks (Sin and Yew 2016).

One of the simplest and most common approaches for the fish stock assessment is Surplus Production Model (Kekenusa et al 2014a, Bordet et al 2014). This Surplus Production Model (SPM) only uses the annual data of catch and fishing effort. Both of the models are used to determine the optimum level of effort that can produce a Maximum Sustainable Yield (MSY). The application of classic SPM for stock assessment usually used one of three growth model approaches, namely, logistic models, Gompertz models, and general logistical models. The various types of SPM were commonly used to estimate the biological reference points (C_{MSY} and E_{opt}) which were highly dependent on the growth function approach used by each model. Therefore it was very important to evaluate the best-fitted model. Using different SPM to obtain the best-fitted model has also been conducted by several researchers (Anna et al 2017, Beset et al 2017, Mayalibit et al 2014, Kumaat et al 2013, Colvin et al 2012). Determination of the best-fitted model was examined based on sign suitability tests as well as the model performance test (Singh 2015, Siyal et al 2013, Moriasi et al 2007, Seong et al 2015, Valero et al 2007).

These biological reference points will be used to estimate the exploitation level (C/C_{MSY}) and the fishing effort level (E/E_{opt}) where both were key factors that need to be balanced in order to the fishing effort can be sustainable. Therefore it is very important to assess whether the current fish abundance is inadequate fish stock conditions and whether the fishing pressure level is sufficiently controlled. This study's aim was to estimate the stock status of *Lutjanus* sp. in the Banyuasin Coastal Waters based on the biological reference points. For the fisheries manager, assessing the current stock status was required to baseline data in order to control the levels of fishing effort and exploitation. This controlling is useful to keep the sustainability of fish stocks in the future.

2. Materials and Methods

2.1. Study area

This study was carried out at the coastal area of Banyuasin Regency, Province of South Sumatra, Indonesia (figure 1). These waters have an estuary which gets water mass input from two different rivers (Banyuasin River and Telang River). At the estuary opening, this water faces directly to the Bangka Strait. The Banyuasin coastal waters are the most significant waters contributing to the capture fisheries production in South Sumatra Province.

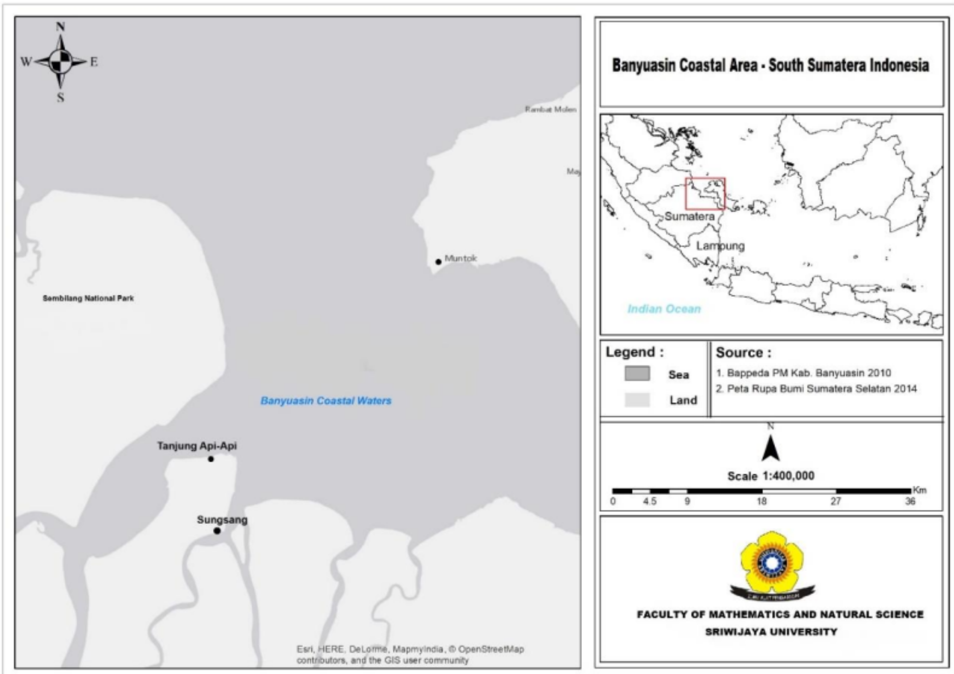


Figure 1. Map of Banyuasin Coastal Waters, Province of South Sumatra, Indonesia.

2.2. Source of data

The annual data of the catch and effort for *Lutjanus* sp. during 2008-2016 were used and obtained from the Annual Report of the Capture Fishery Statistics of Banyuasin Regency, South Sumatra. The fishing effort was obtainable by a number of the operational fishing boat (trip) and the total catch was presented in the total weight of fish landed (Beset et al 2017).

2.3. CPUE and effort standardization

The catchability of each fishing gear to catch the target species was different so that the standardization technique of fishing gears was needed (King 1995, Sparre and Venema 1998, Fauziyah et al 2018c). The formula of fishing gear standardization as following:

$$E_{jt} = \varphi_{jt} D_{jt}$$

$$\varphi_{jt} = \frac{U_{jt}}{U_{st}}$$

$$U_{jt} = \frac{C_{jt}}{D_{jt}}$$

Where,
E_{jt} = Effort from gear *j* at *t* standardized
D_{jt} = Effort from gear *j* at *t* period (trip)

φ_{jt} = Fishing power of gear *j* at *t* period
U_{jt} = Catch per unit effort (CPUE) of gear *j* at *t* period
U_{st} = Catch per unit effort (CPUE) standardized
U_{jt} = Catch per unit effort (CPUE) of gear *j* at *t* period (ton/ trip)
C_{jt} = the catch of gear *j* at *t* period (ton)

2.4. Surplus Production Model

Table 1 presented the vary SPMs equations that were used in this study. The sustainable catch equation for Schaefer, Gulland, Walter and Hilborn, and Schnute models used the logistic growth. Fox and CYP models used Gompertz growth, while Pella & Tomlinson model was used the generalized logistic growth.

Table 1. The equations for SPM and reference points.

Model	Equation	Biological References Point	References
1. Schaefer	$\frac{C_t}{\bar{E}_t} = \alpha - \beta E_t$; $C_t = aE_t - bE_t^2$	$E_{opt} = \frac{a}{2b}$ $C_{MSY} = \frac{a^2}{4b}$	(Kekenusa et al 2014b, 2015, 2018)
2. Gulland	$U_t = \frac{C_t}{\bar{E}_t} = a - b\bar{E}_t$ $C_t = a\bar{E}_t - b\bar{E}_t^2$	$E_{opt} = \frac{a}{2b}$ $C_{MSY} = \frac{a^2}{4b}$	(Singh 2015, Ricker 1975, Widodo 1986)
3. Pella & Tomlinson	$U_t = \frac{C_t}{E_t} = a - bE_t^{m-1}$ $C_t = aE_t - bE_t^m$	$E_{opt} = \left(\frac{a}{mb}\right)^{(1/(m-1)}$ $C_{MSY} = aE_{opt} + bE_{MSY}^m$	(Singh 2015, Widodo 1986)
4. Fox	$Ln\left(\frac{C_t}{E_t}\right) = a - bE_t$ $C_t = E_t\,Exp(a - bE_t)$	$E_{opt} = \frac{1}{b}$ $C_{MSY} = \frac{1}{b}\,exp(a-1)$	(Kekenusa et al 2014b, 2015, 2018, Mohsin et al 2017)
5. Walters-Hilborn	$\frac{U_{t+1}}{U_t} - 1 = a + bU_t + cE_t$ $C_t = KqE_t - \frac{Kq^2}{r}E_t^2$ a=r; q=-c; K= a/(bc)	$E_{opt} = -\frac{a}{2c} = -\frac{r}{2q}$ $C_{MSY} = \frac{a^2}{4b} = \frac{rK}{4}$	(Kekenusa et al 2014b, 2015, 2018)
6. Schnute	$Y_t = a + bX_{it} + cX_{2t}$ $C_t = KqE_t - \frac{Kq^2}{r}E_t^2$ Y_t=Ln(U_{t+1}/U_t); X_{1t}=½(U_t+U_{t+1}); X_{2t}=½(E_t+E_{t+1}); a=r; q=-b; K= a/(bc)	$E_{opt} = -\frac{a}{2c} = -\frac{r}{2q}$ $C_{MSY} = \frac{\alpha^2}{4b} = \frac{rK}{4}$	(Kekenusa et al 2014b, 2015, 2018, Sholahuddin et al 2015)
7. CYP	$Y_t = a + bX_{it} + cX_{2t}$	$E_{opt} = \frac{r}{q}$	(Kekenusa et al 2014b, 2015, 2018,

Model	Equation	Biological References Point	References
	$C_t = KqE_t exp\left(\frac{-q}{r}E_t\right)$ Y_t=ln(U_{t+1}); X_{1t}=ln(U_t); X_{2t}=(E_t+E_{t+1}); a=âln(qK); r=2(1- b)/(1+ b) q=-c(2+r); $K = e^Q/q$ Q= a(2+r)/(2r)	$C_{MSY} = \frac{a^2}{4bc} = \frac{rK}{e}$	Supriatna et al 2016)

Note:

E_t	=	effort standardized at *t* period
$\bar{E}_t$	=	moving average of effort standardize at *t* periode
E_{t+1}	=	effort standardized at *t+1* period
C_t	=	catch at *t* period
U_t	=	CPUE standardized at *t* period
U_{t+1}	=	CPUE standardized at *t+1* period
r	=	intrinsic growth rate
q	=	catchability coefficient
K	=	carrying capacity
a,b,c	=	regression coefficients

2.5. *Best-fitted Model*

The determination of the best-fitted model was examined based on the sign suitability tests as well as the model performance test. Table 2 presented the estimation parameters of SPM that used for testing the sign suitability. Schaefer, Pella & Tomlinson, Fox, and Gulland models used intercept value (a) and slope value (b) for testing the sign suitability. While Walters-Hilborn, Schnute, and CYP model using the value of r, q, and K for testing the sign suitability (Kekenusa et al 2014a, 2014b, 2015, 2018, Sparre and Venema 1998). The SPMs with the appropriate parameter sign proceeded with the model performance test.

All aspects of the model performance can not assess using a single statistic and there was no clear consensus to measure the model performance. Some authors used several statistic parameters to assess the model performance, such as R^2, NSE, RMSE, MAD, MSE, MAPE, and RSR (Moriasi et al 2007, Valero et al 2007, Seong et al 2015, Singh 2015). Walters-Hilborn, Schnute, and CYP model used the multiple regressions, whereas Schaefer, Pella & Tomlinson, Fox, and Gulland model used the simple regression. Basically, R^2 was obtained from a regression between CPUE (Y-axis) and Effort (X-axis). The formula of the statistical parameter for assessing the model performance was presented in Table 3.

Table 2. The estimation parameters of SPM that used for testing the sign suitability.

Model	Estimation parameters	Sign suitability test
1. Schaefer	a (intercepts)	The a value must be positive (+)
	b (slope)	The b value must be negative (-)
2. Gulland	a (intercepts)	The a value must be positive (+)
	b (slope)	The b value must be negative (-)
3. Pella & Tomlinson	a (intercepts)	The a value must be positive (+)
	b (slope)	The b value must be negative (-)
4. Fox	b (slope)	The b value must be negative (-)

Model	Estimation parameters	Sign suitability test
5. Walters-Hilborn	r	The r value must be positive (+)
	q	The q value must be positive (+)
	K	The K value must be positive (+)
6. Schnute	r	The r value must be positive (+)
	q	The q value must be positive (+)
	K	The K value must be positive (+)
7. CYP	r	The r value must be positive (+)
	q	The q value must be positive (+)
	K	The K value must be positive (+)

Table 3. The statistical parameters for assessing the SPM performance

Statistics parameters	Formula	Performance criteria	Ref.
1. Determination coefficient (R^2)	Multiple regression: $R^2 = \frac{(b\sum x_1 y) + (c\sum x_2 y)}{\sum y^2}$ Simple regression: $R^2 = \frac{\left(n(\sum XiYi) - (\sum Xi)(\sum Yi)\right)^2}{n\sum Xi^2 - (\sum Xi)^2}$	Very Good : $0.86 < R2 \leq 1$ Good : $0.75 < R2 \leq 0.86$ Satisfactory : $0.65 < R2 \leq 0.75$ Unsatisfactory : $0.65 < R2 \leq 0.75$	Duda et al 2012)
2. Mean absolute deviation (MAD)	$MAD = \frac{\sum\lvert C_t - \hat{C}_t\rvert}{n}$	The lower the MAD value, the model performance is better.	(Moriasi et al 2007)]
3. Mean square error (MSE)	$MSE = \frac{\sum(C_t - \hat{C}_t)^2}{n}$	The lower the MSE value, the model performance is better.	(Moriasi et al 2007)
4. Root mean square error (RMSE)	$RMSE = \left[\frac{\sum(C_t - \hat{C}_t)^2}{n}\right]^{\frac{1}{2}}$	The lower the RMSE value, the model performance is better.	(Moriasi et al 2007)
5. Mean absolute percentage error (MAPE)	$MAPE = \frac{\sum\left\lvert\frac{C_t - \hat{C}_t}{C_t}\right\rvert}{n}$	Very Good : MAPE < 0.1 Good : $0.1 \leq$ MAPE < 0.2 Satisfactory : $0.2 \leq$ MAPE < 0.5 Unsatisfactory : MAPE ≥ 0.5	[36]
6. RMSE-observations Standard Deviation Ratio (RSR)	$RSR = \sqrt{\frac{\sum(C_t - \hat{C}_t)^2}{\sum(C_t - \bar{C})^2}}$	Very Good : $0.00 \leq RSR \leq 0.50$ Good : $0.50 < RSR \leq 0.60$ Satisfactory : $0.60 < RSR \leq 0.70$ Unsatisfactory : $RSR > 0.70$	(Moriasi et al 2007)
7. Nash-Sutcliffe Efficiency (NSE)	$NSE = 1 - \frac{\sum(C_t - \hat{C}_t)^2}{\sum(C_t - \bar{C})^2}$	Very Good : $0.75 < NSE \leq 1.00$ Good : $0.65 < NSE \leq 0.75$	(Moriasi et al 2007)

Statistics parameters	Formula	Performance criteria	Ref.
		Satisfactory : $0.50 < NSE \leq 0.65$	
		Unsatisfactory : $NSE \leq 0.50$	

Note:

$\hat{C}_t$: the predicted catch at t period
C_t : the actual catch at t period
$\bar{C}$: the mean of actual catch
n : the number of observations

The best-fitted model using several criteria (table 3) and selected based on multi-criteria analysis (MCA). The MCA would calculate the standardized value for all criteria of the model performance. The standardization formula (Iskandar and Guntur 2014, Wiyono 2011, Fauziyah et al 2018b) as follows:

1. For R^2 and NSE criteria:

$$V(X) = \frac{X - X_0}{X_a - X_0}$$

2. For MAD, MSE, RMSE, MAPE and RSR criteria:

$$V(X) = \frac{X_a - X}{X_a - X_0}$$

3. The value functions for decision making:

$$V(A) = \sum_{i=a}^{n} Vi(Xi)$$

$$i = a, b, c, d \ldots\ldots n$$

Where:

V(X) = Value function of criteria X
X = Value of criteria X
Xa = The highest value of criteria X
Xo = The lowest value of criteria X
V(A) = Value function of alternatives A
Vi(Xi) = Value function of alternatives in criteria i

The best-fitted model was determined based on the highest V(A) value (Iskandar and Guntur 2014, Wiyono 2011, Fauziyah et al 2018b).

2.6. Fish stock status

The classification method for determining the fish stock status varies between researchers as well as varies between country (Garcia et al 1989, Beddington et al 2007, Pauly 2007, 2008, Carruthers et al 2012). This study modified the classification of fish stock status by considering the C/C_{MSY} and E/E_{opt} as the biological reference points (table 4).

Table 4. The classification of fish stock status

The fisheries status and criterion		The fish stock status
Exploitation level	**Fishing Effort Level**	
Over-exploited ($C/C_{msy} \geq 1$)	Underfishing ($E/E_{opt} < 1$)	Healthy Stock
Over-exploited ($C/C_{MSY} \geq 1$)	Overfishing ($E/E_{opt} \geq 1$)	Depleting Stock
Fully-exploited ($0.5 \leq C/C_{MSY} < 1$)	Underfishing ($E/E_{opt} < 1$)	Recovery Stock
Fully-exploited ($0.5 \leq C/C_{MSY} < 1$)	Overfishing ($E/E_{opt} \geq 1$)	Overfishing Stock
Moderate exploited ($0.2<C/C_{MSY} < 0.5$)	Overfishing ($E/E_{opt} \geq 1$)	Overfishing Stock
Moderate exploited ($C/C_{MSY} < 0.5$)	Underfishing ($E/E_{opt} < 1$)	Transitional recovery Stock
Moderate exploited ($C/C_{MSY} \leq 0.2$)	Overfishing ($E/E_{opt} \geq 1$)	Collapsed stock

3. Result and Discussion

3.1. Catch, Effort and CPUE

Table 5 presented the data of catch, standard effort, and CPUE where the trammel net was the standard fishing gears for this analysis. Increasing the CPUE value occurred during the 2008-2009 period and then tended to decline until 2016. Decreasing the CPUE value in 2010-2016 due to the proportion for increasing the catch was smaller than the proportion of the increase in fishing efforts. Decreasing the CPUE values indicated that the species encounter the overfishing phenomenon (Mayalibit et al 2014).

Table 5. The number of catches (ton), fishing efforts (trip), and CPUE (ton/trip) of *Lutjanus* sp. from the Banyuasin Coastal waters during 2008-2016.

Year	Actual Catch (ton)	Standard effort (trip)	CPUE (ton/trip)
2008	543.04	12961.54	0.04190
2009	561.59	11438.37	0.04910
2010	564.67	16585.72	0.03405
2011	540.74	29252.38	0.01849
2012	578.73	29252.38	0.01978
2013	596.06	27195.44	0.02192
2014	598.52	29425.35	0.02034
2015	617.91	31631.64	0.01953
2016	633.83	31398.36	0.02019

3.2. The best-fitted SPMs

The best-fitted model for *Lutjanus* sp. was selected from various SPM (table 6). Based on the sign suitability test, Walter-Hilborn, Schnute, and CYP model were not adequate for this species. Fox model was the best-fitted model for *Lutjanus* sp. based on the MCA value (V(A) = 6.968). The values of R^2, NSE, MAD, MSE, RMSE, MAPE and RSR for this model were 0.972, -0.277, 29.198, 1,190.522, 34.504, 0.050 and 1.130 respectively. The Fox model had the best value for NSE, MAD, MSE, RMSE, MAPE and RSR whereas the Pella & Tomlinson model only had the best value on R^2 criteria. According to the value of R^2 and MAPE, the Fox model performance was very good (Duda et al 2012, Moreno et al 2013). The value of E_{opt}, C_{MSY}, and TAC were 22,236 trips, 623 ton and 498 ton respectively.

Table 6. Summary statistics from various SPM of *Lutjanus* sp in Banyuasin Coastal Waters.

Parameter	SPM_1	SPM_2	SPM_3	SPM_4	SPM_5	SPM_6	SPM_7
Sign Suitability Test							
a	0.060424	0.056314	-2.575429	0.310822	-0.77460	- 5.43187	- 5.2697
b	-0.000001	- 0.000001	-0.000045	-0.103878	7.06378	84.34071	- 1.0490
c					0.00002	0.00013	- 0.00005
r					-0.775 NA	- 5.432 NA	- 83.549 NA
K					-0.00002 NA	- 0.00013 NA	- 0.0038 NA
q					- 5,003.154 NA	-514.5002 NA	- 20.206 NA
m	-	-	-	1.1			
Performance Test							
R^2	0.951	0.773	0.972	0.977			
NSE	- 1.796	-2.424	- 0.277	- 0.419			
MAD	43.991	44.173	29.198	31.228			
MSE	2,607.374	3,193.380	1,190.522	1,323.228			
RMSE	51.062	56.510	34.504	36.376			
MAPE	0.075	0.075	0.050	0.054			
RSR	1.672	1.850	1.130	1.191			
Biological references point							
E_{opt}	22,178	22,442	22,236	22,179			
C_{MSY}	670	632	623	627			
TAC	536	506	498	501			
MCA value							
V(A)	1.952	0.010	**6.972**	6.430			

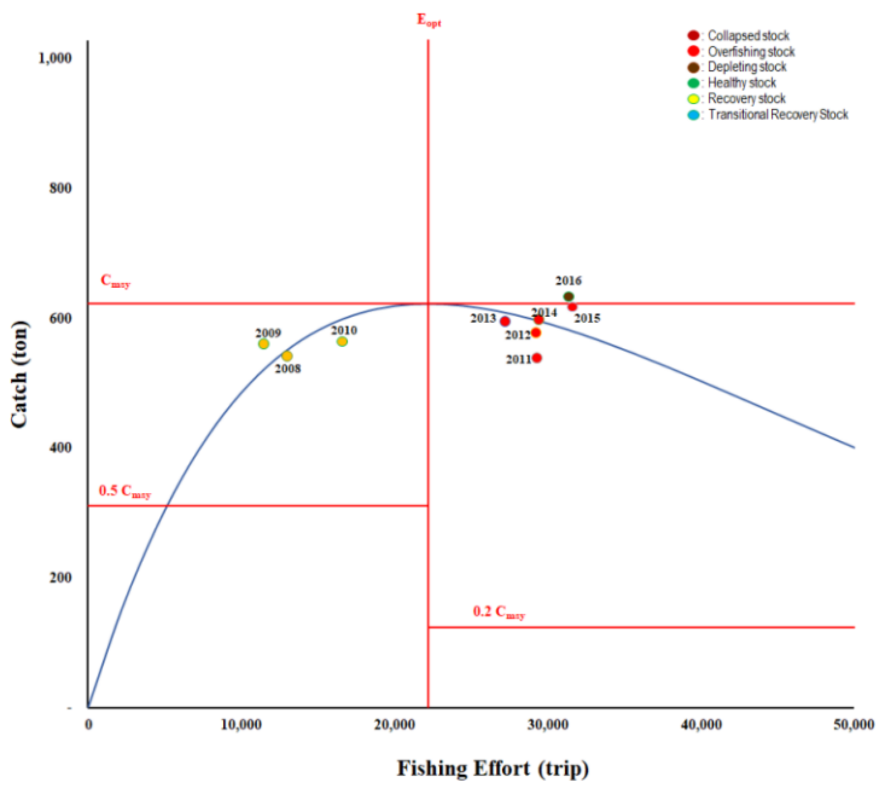
Note:
SPM_1: Schaefer
SPM_2: Gulland
SPM_3: Fox
SPM_4: Pella and Tomlinson
SPM_5: Walter-Hilborn
SPM_6 : Schnute
SPM_7: CYP
NA : Not Appropriate
V(A) : Scoring value

Similar to this study result, the Fox model also as the best-fitted model for the yellowstripe scad (*Selaroides leptolepis*) from Karangantu Banten (Mayalibit et al 2014), and Skipjack tuna (*Katsuwonus pelamis*) from Bolaang-Mongondow Waters of North Sulawesi (Kekenusa et al 2014a).

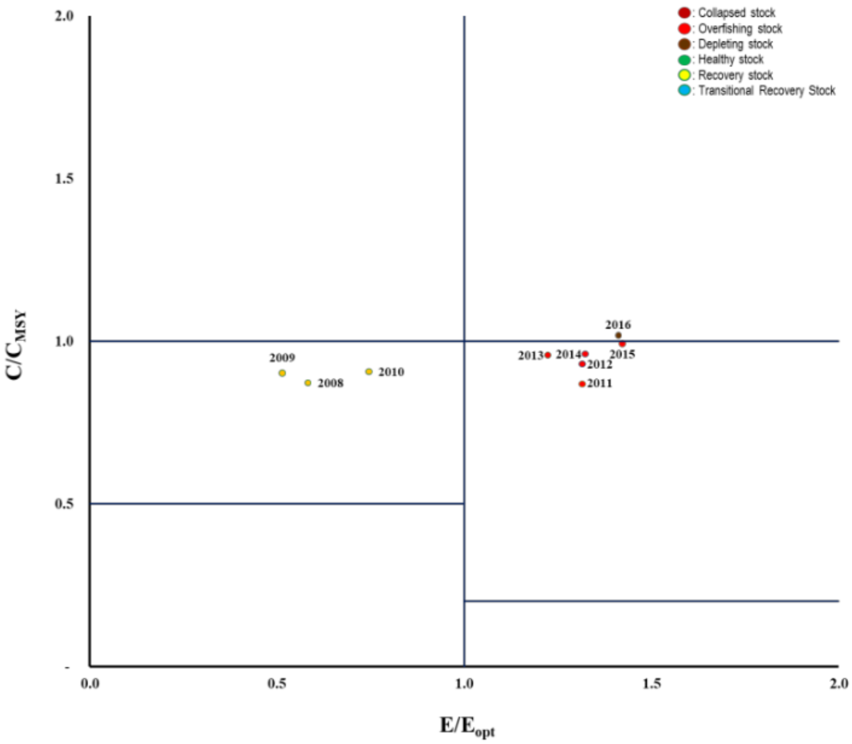
On the West Coast of Peninsular Malaysia (Sin and Yew 2014), the CYP model was selected as the best-fitted model for the pelagic and demersal fish.

3.3. Fish stock status

Figure 2 showed the fluctuation of fisheries development for *Lutjanus* sp. during the 2008-2016 period. In the 2008-2010 period, the exploitation level of *Lutjanus* sp. was fully-exploited ($0.5 \leq C/C_{MSY} < 1$) whereas the fishing effort level was underfishing ($E/E_{opt} < 1$) and this condition indicated recovery stock. During 2011-2015 period, occurring an increase in the level of fishing efforts until exceeding the optimum point ($E/E_{opt} \geq 1$) but the level of exploitation was still fully-exploited ($0.5 \leq C/C_{MSY} < 1$) so that the stock status was overfishing. Whereas in 2016, the exploitation level increased to exceed the optimum point ($C/C_{MSY} \geq 1$) and there were a few decreases in the level of fishing effort even though it still exceeded the optimum point ($E/E_{opt} \geq 1$). Thus, the stock status in 2016 showed a depleting stock. In these conditions, even though the abundance of fish stocks is still high (the actual catch obtained could exceed the CMSY value) but the fishing rate is also high (the fishing effort exceed the E_{opt} value). This phenomenon can encourage an overfishing stock in the future when both the catch landed and the fishing effort can't be controlled.



A. Ploting Fox model and fish stock status.



B. Plotting effort level, exploitation level, and fish stock status.

Figure 2. Fish stock status for *Lutjanus* sp. in Banyuasin Coastal Waters.

These study results were in line with the stock assessment of *Lutjanus* sp. in the mayor fishing ground of the Australian and Indonesia Waters Fisheries (Koeshendrajana et al 2018) where the efforts level in 2015 has exceeded the optimum point ($E/E_{opt} > 1$). Overfishing for *Lutjanus* sp. also occurred in Cirebon Waters in 2012 period (Noija et al 2014). Ideally, the level of exploitation and fishing effort needs to be limited so that it does not exceed the biological reference point ($C/C_{MSY} = 1$; $E/E_{opt} = 1$). Reducing the fishing vessel number is essential besides promoting the development of environmental-friendly fishing gear in order to reduce the fishing efforts and rebuild overfishing stocks (Siyal et al 2013, Chae and Pascoe 2005). Updating the fish stock status constantly is also important for fisheries management (Meraz-Sánchez et al 2013).

Based on the TAC value limit (TAC = 498 ton/year), the catch of *Lutjanus* sp. during 2008-2016 has been exceeded the limit value. In these conditions, limiting output (production or fish landed) and/or effort for each fishing gear was necessary to consider as one of policy to protect the resources from overfishing (Anna 2016). For fishermen, the effort reduction will reduce income, but not significantly generate a financial loss due to the operational fishing costs will be reduced too (Sobari et al 2008). To avoid financial loss, fishermen can also manage fishing trips (Sobari et al 2008). For the fishery manager, some serious steps can be created to control the efforts and mesh size, control TAC, protect the nursery grounds to maintain the natural process, and conduct a detailed study for better understanding of fishery (Beset et al 2017).

4. Conclusion

The stock status of *Lutjanus* sp. in the Banyuasin Coastal Waters has been depleting since 2016. Although the biomass was still quite high, the fishing pressure was also high (exceeding the optimal effort level). This condition could encourage an overfishing stock if the catch and the fishing effort could be controlled for ensuring the sustainability of these fish resources.

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