Assessing the stock status of giant catfish (*Netuma thalassina*) in Banyuasin coastal waters, South Sumatra of Indonesia

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Abstract. This study aimed to determine the stock status for *Netuma thalassina* from the Banyuasin coastal waters using Pella & Tomlinson model. The annual catch and effort data (2008-2016) were taken from the Department of Fisheries and Marine, Banyuasin Regency, Province of South Sumatera, Indonesia. The fish stock status was classified based on the fishing effort level (FEL) and exploitation level (EL). The optimum effort (E_{msy}), maximum sustainable catch (C_{msy}), and total allowable catch (TAC) were 31,775 trips year^{-1}, 1,979, and 1,584 ton year^{-1}, respectively. The FEL and EL values in 2016 were 108% (overfishing) and 110% (overexploited), respectively. This result indicated that the stock status of *N. thalassina* was a depleting stock.
Key Words: Banyuasin, *Netuma thalassina,* stock status, surplus production model.

Introduction. Banyuasin coastal waters are a center of fishing activities in South Sumatra Province with a high potential of marine resources and diversity (Fauziyah et al 2018; Fauziyah et al 2019b). The species abundance in this waters was affected by changes in environmental conditions that were strongly influenced by the condition of the Musi River inflow (Fauziyah et al 2019a). One of the important economic fish in this water is giant catfish (*Netuma thalassina*) which is known by the national name as Manyung and Duri Utik for local names. The distribution area of *N. thalassina* is all coastal and offshore waters of Indonesia, especially Java, Sumatra, Kalimantan, South Sulawesi, and Arafura (Genisa 1999). The total length can reach 185 cm but the size that is often caught is less than 100 cm (Genisa 1999; Marbun et al 2017). This species is one of the demersal fish that has important economic potential (Genisa 1999; Taunay et al 2013) and became one of the leading commodities for fisheries in the Province of South Sumatra, Indonesia and the utilization level for 2007 was 65.02% (Septifitri et al 2010).

The current stock of *N. thalassina* in Banyuasin coastal waters is unknown due to research on fish resources is very limited. Based on Banyuasin fisheries statistics, the production of *N. thalassina* fluctuated for the period 2008 to 2016. A decline in production occurred in 2008-2011 and subsequently increased in 2012-2016. In 2008, *N. thalassina* production was 1,832.34 tons, then decreased to 1,812.67 tons in 2011 while in 2016 it increased 2,176.18 tons (BPS-Statistics of Banyuasin Regency 2018). Open access fishing in these waters may be one of the factors that influence the occurrence of catches fluctuations. In the term of open access, every user/fisherman can use it unlimitedly which results in inefficient use of resources (Patria et al 2014) and less responsible fishing (Nurhayati 2013). The increasing fishing capacity induces high fishing pressure on fish stock dynamics, then it subsequently results in an over-exploitation even the available fish stocks will be depleted (Sin & Yew 2016). Therefore, a stock status assessment of *N. thalassina* from the Banyuasin coastal waters is needed, even though it can be used for consideration in determining the appropriate management strategy.

The fishing effort level (E/E_{msy}) and exploitation level (C/C_{msy}) were two key factors that should be managed to keep fish stock sustainability (Fauziyah et al 2020). Through these values, a time series of stock status could be estimated and useful for assessing whether the fishing activities have been sustainable based on the fish stock status. This study aims to assess the fish stock status of *N. thalassina* from the Banyuasin coastal waters using Pella & Tomlinson model. The stock assessment results were expected to be used as consideration in determining the action plan for capture fisheries management, which eventually can affect the future stock conditions.

Material and Method

Study area. This research was carried out in July-October 2018 at the coastal of Banyuasin Regency, Province of South Sumatra, Indonesia (Figure 1). The local fishermen captured *N. thalassina* in the Banyuasin coastal waters including: 1) the estuary of Tempilang, Sembilang, Bedawang, Bungin, Musi, Benuh, Barong; 2) the waters around Tanjung Carat, Tanjung Niur, Pulau Tujuh, Nipa Panjang, Tanjung Api-Api; 3) the waters around the Birik Sea, Bangka Sea.

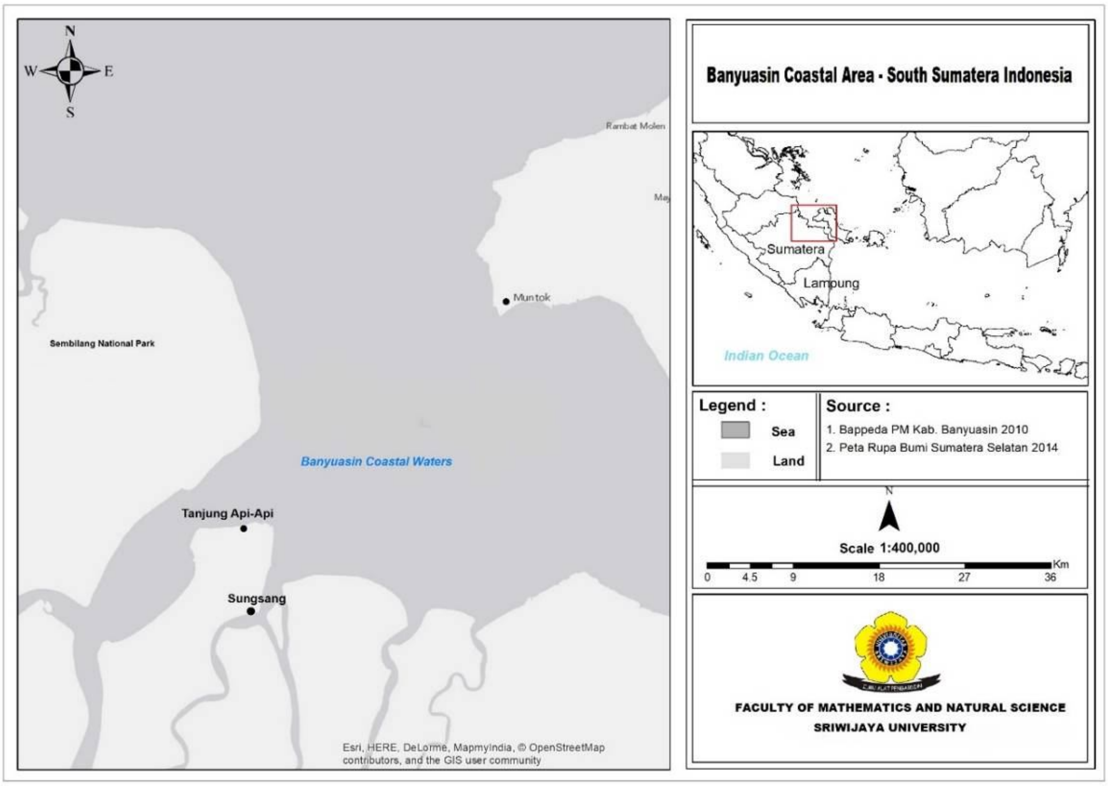

Figure 1. Map of Banyuasin coastal waters, Province of South Sumatra, Indonesia.

Source of data. The data used in this study include both primary and secondary data for the estimation of the parameter and contents of the mathematical equations (Sin & Yew 2016). The annual catch and effort data of *N. thalassina* were obtained from the Annual Fishery Statistics of Banyuasin Regency, South of Sumatra during the years 2008-2016. Fishing effort is obtainable by the number of operational fishing boats (trip) and the total catch is presented in the weight of catch (Baset et al 2017). For this study, the data (production and trip) were classified based on the type of fishing gear used by Banyuasin fishermen to catch *N. thalassina*, namely Danish seines, drift gillnet, trammel net, hook and line as well as traps. The time fishing trips for these fishing gears were one day trip.

Data analysis. Data analysis of catch per unit effort (CPUE), fishing gear standardization, Pella & Tomlinson model, the sustainable effort (E_{msy}), sustainable catches (C_{msy}), total allowable catch (TAC), the fishing effort level (FEL) and exploitation level (EL), and fish stock status were used in this study (Sparre & Venema 1998; Anna 2016; Anna et al 2017; Anna 2018; Fauziyah et al 2020). This study has used the classification of fish stock status according to the previous study (Fauziyah et al 2020) namely the healthy stock, depleting stock, recovery stock, overfishing stock, transitional recovery stock, and collapsed stock. For describing these classifications, the Kobe Plot diagram was used that allows comparing the ratio C/Cmsy (the EL value) and the ratio E/Emsy (the FEL value) by using a big plot diagram for illustrating the stock status trajectories (Atmadja et al 2017; Winker et al 2017; Fauziyah et al 2020).

Results. The data of production (catch), standard effort, and CPUE *for N. thalassina* in the coastal waters of Banyuasin in the period 2008-2016 were presented in Table 1. The standardized effort for this species was obtained from the standardization of fishing gears (Danish seines, drift gillnet, trammel net, hook and lines, and trap) from 2008 to 2016. And the trammel net was used as standardized fishing gear. Based on Table 1, the highest CPUE values occurred in 2009 and then decreased to the lowest value in 2011, and in subsequent years, CPUE values increased relatively even though they did not exceed the CPUE value in 2008. Mathematically, decreasing CPUE values in this study occurred due to two conditions. First, the increasing effort was not proportional to the increasing catch. This condition occurred in 2009-2010 whereas in 2010, an increase in effort reached 8,460 trips but the increase in catch was only 3.2 tons. The same case also occurred in 2013-2015. Second, the increasing effort did not result in increasing catches. This condition occurred in 2010-2011 where the increasing effort in 2011 reached 7,575 trips, but instead, the catch decreased by 0.73 tons.

Table 1

The number of catches (ton), fishing efforts (trip), and CPUE (ton/trip) of *N. thalassina* in the Banyuasin Coastal waters in 2008-2016

Year	*Actual catch (ton)*	*Standard effort (trip)*	*CPUE (ton/trip)*
2008	1,832.34	20,795	0.08811
2009	1,810.20	18,791	0.09633
2010	1,813.40	27,251	0.06655
2011	1,812.67	34,826	0.05205
2012	1,858.96	34,826	0.05338
2013	1,910.13	29,718	0.06427
2014	2,060.64	32,028	0.06434
2015	2,128.37	34,429	0.06182
2016	2,176.18	34,344	0.06336
Average	1,933.65	29,667	0.0678

Note: the trammel net was used as standardized fishing gear.

For the further analysis, the Pella & Tomlinson model was used to estimate the sustainable effort (E_{msy}), sustainable catches (C_{msy}), total allowable catch (TAC), and to determine the stock status of *N. thalassina* resources in the Banyuasin coastal waters.

The C_{msy}, E_{msy}, TAC, FEL, and EL for *N. thalassina* in Banyuasin coastal waters were presented in Table 2. The E_{msy}, C_{MSY}, and TAC values were 31,775 trip year^{-1}, 1,979 ton year^{-1}, and 1,584 ton year^{-1} respectively. There were some actual catches higher than the C_{msy} value and E_{msy} value. The FEL values in 2011, 2012, 2014, 2015 and 2016 were 110%, 110%, 101%, 108%, and 108%, respectively. The values indicated that the actual catch exceeded the E_{msy} value (overfishing). Under fishing (FEL < 1) occurred in 2008, 2009, 2010, and 2013. The EL values in 2014, 2015, and 2016 were 104%, 108%, and 110%, respectively where the values indicated that the actual catch exceeded the C_{msy} (over-exploited). Fully-exploited (0.5 < EL < 1) occurred in 2014, 2015, and 2016. Plotting the FEL values for X-axis and EL values for Y-axis (Figure 2) was used as a basis for describing the fish stock status.

Table 2

The level of fishing effort (FEL) and exploitation level (EL) of *N. thalassina* in the Banyuasin Coastal waters in 2008-2016

Year	*Actual catch*	*Standard effort*	*Pella & Tomlinson model*			*FEL (%)*	*EL (%)*
			E_{msy}	C_{msy}	*TAC*		
2008	1,832.34	20,795	31,775	1,979	1,583.6	65%	93%
2009	1,810.20	18,791				59%	91%
2010	1,813.40	27,251				86%	92%
2011	1,812.67	34,826				110%	92%
2012	1,858.96	34,826				110%	94%
2013	1,910.13	29,718				94%	96%
2014	2,060.64	32,028				101%	104%
2015	2,128.37	34,429				108%	108%
2016	2,176.18	34,344				108%	110%

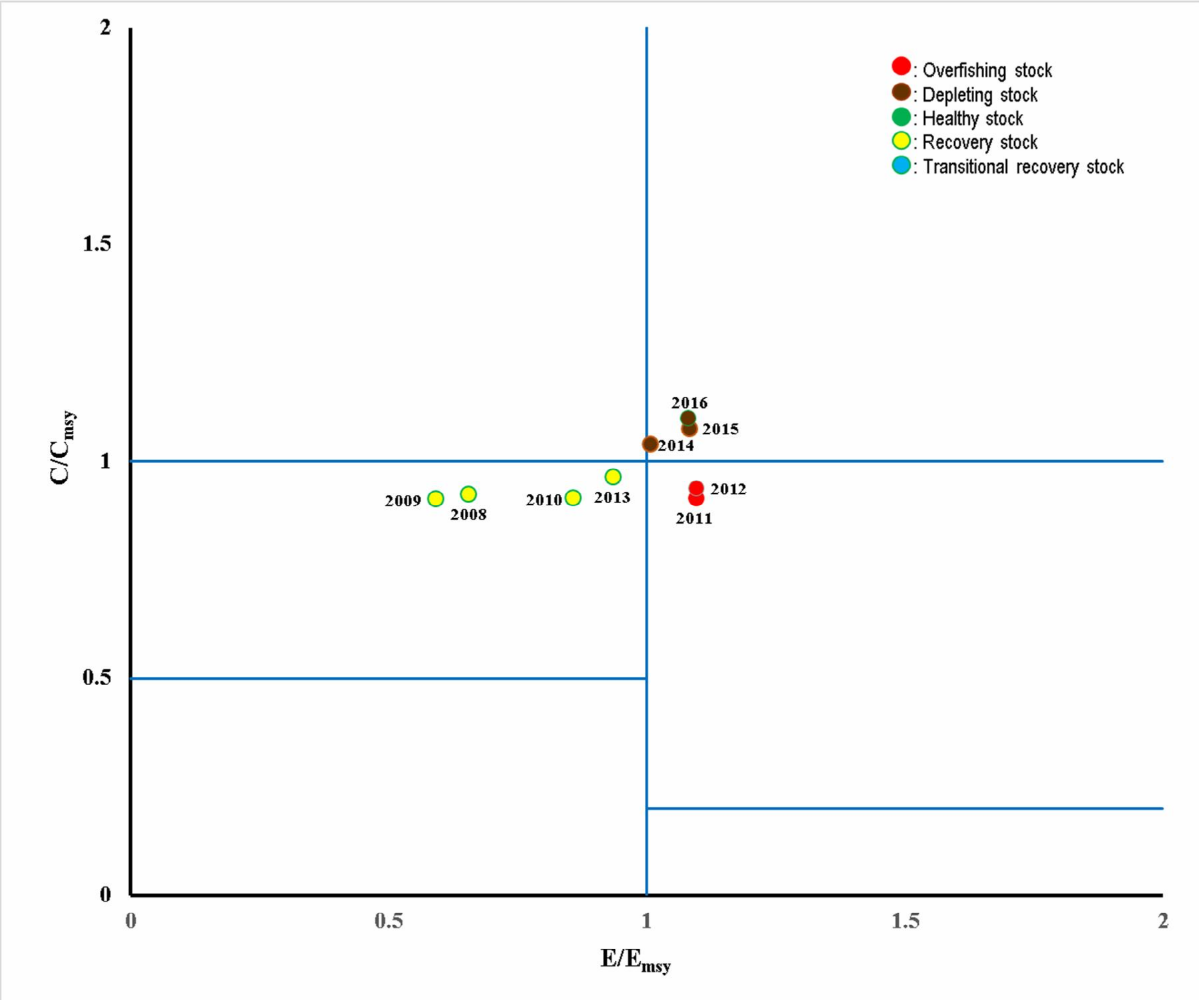

Figure 2. The stock status plot of *N. thalassina* in the Banyuasin coastal waters in 2008-2016 based on the E/E_{msy} and C/C_{msy} values.

Figure 2 showed that the recovery stock (FEL < 1; 0.5 < EL < 1) occurred in 2008, 2009, 2010 and 2013. Overfishing stock (FEL > 1; 0.2 < EL < 1) occurred in 2011 and 2012 whereas depleting stock (FEL > 1; EL > 1) occurred in 2014, 2015 and 2016. In this results, the condition of healthy stock (FEL < 1; EL > 1) or collapsed stock ((FEL > 1; 0 < EL < 0.2) or transitional recovery stock (FEL < 1; 0 < EL < 0.5) never occurred during the 2008-2016 period.

Discussion. This study results indicated that the catch in 2016 exceeded the C_{msy} limit (EL > 100%). Those results were different from the stock assessment in 2006, where the EL for *N. thalassina* in South Sumatra (Banyuasin and Ogan Komering Ilir Regencies) was still 65.02% (Septifitri et al 2010). The C_{msy} is not an absolute indicator for fisheries management, because the catch based on official statistics does not reflect the actual catch due to the fisheries system is still at the level expansion. Therefore, the condition and status of fish stocks are described based on relative fishing mortality and relative biomass (Atmadja et al 2017) or known as Kobe Plot. Based on the stock-status plots, the dynamics of *N. thalassina* stock status in Banyuasin coastal waters in 2008-2016 can be grouped into three categories, namely, recovery stock (2008, 2009, 2010, and 2013), overfishing stock (2011-2012), and depleting stock (2014-2016).

In the term of depleting stock, the abundance of fish stocks is still high (the actual catch obtained could exceed the C_{msy} value) but the fishing rate is also high (the fishing effort exceed the E_{msy} value) so that it can encourage overfishing stock in the future. Stock conditions in 2014-2016 were better than stock conditions in 2011-2012 (overfishing stock). In the term of overfishing stock, the abundance of fish stocks was low (the actual catch obtained could not exceed the C_{msy} value) due to high fishing rates (the fishing effort exceed the E_{msy} value) so that stocks were not sustainable and the risk of collapsed stock was higher. The main factors causing a bad status of the fish stocks include the effort system ineffectiveness to control the fishing mortality, the inadequacies management plans, and the scientific advice is not constantly obeyed (Cardinale & Scarcella 2017; Froese et al 2018).

Overfishing can be detected using a combination of several stock indicators, such as (i) decrease in catch per unit effort, (ii) decrease in landed total catch, (iii) decrease in average fish weight/size, (iv) changes in age structure/size structure, and or (v) changes in species composition in the population (Septifitri et al 2010). This condition must be anticipated by improving fish habitat, increasing understanding and awareness of fishermen to maintain coastal balance, the implementation of the system of monitoring, controlling, and surveillance (MCS), management of capture fisheries zone (Nurhayati 2013; Kekenusa et al 2014). In these conditions, it is necessary to consider a policy on limiting output (production) and/or effort of each fishing gear (Anna 2016) to protect the resources from overfishing. For fishermen, the reduction of effort will reduce income, but it will not too inflict a financial loss of fishermen because it will reduce the operational costs for fishing (Sobari et al 2009). Besides the reduction in fishing effort, the arrangement of the fishing day should be made to avoid financial loss. Another solution to maintain the economic stability of fishermen, alternative jobs could be done, like pond business (Sobari et al 2008; Salmah et al 2012). The fishery management can take some serious steps to control efforts and mesh size, protect the nursery grounds to maintain the natural process, control total allowable catch, and detailed study for better understanding of fishery (Baset et al 2017). Increasing awareness of relevant stakeholders to know and maintain a reference point for fisheries management at the optimum biomass level will be very important in supporting the policy of fish resource sustainability (Atmadja et al 2017).

The depleting stock condition that occurred in this study was due to a significant reduction in the fishing effort especially standardized fishing gear (trammel net) in 2013 (31% lower than in 2012) so that the stock recovery process was thought to occur naturally. This condition was supported by the fact that the catch in the next years could exceed the C_{msy} value (one indicator of the stock is still high). In terms of the depleting stock, the current level of fishing effort needs to be limited by strict control (the fishing effort slightly below the E_{msy} value) to avoid overfishing phenomenon.

Conclusions. The C_{msy} value for this species was 1,979 tons year^{-1}, and it is obtained at the optimum fishing effort of 31,775 trip year^{-1}. In 2008-2016, the catch had exceeded the value of total allowable catch (TAC = 1,583.6 ton year^{-1}). The dynamics of *N. thalassina's* stock status in Banyuasin coastal waters in 2008-2016 can be grouped into 3 categories, namely, recovery stock (2008, 2009, 2010, and 2013), overfishing stock

(2011-20112), and depleting stock (2014-2016). We may suggest that a policy is needed to handle this issue to maintain sustainable fish stock.

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