System dynamic modelling for sword and white pomfret fish resources at Depok coast, Bantul

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Abstract. Depok Coast in Bantul Regency popular for fishing activities. The potential for considerable marine resources in Depok Coast is a major factor in the progress of the fisheries business. The potential of these marine resources can provide a great opportunity for the development of capture fisheries and raise the economy of coastal communities. Sword and white pomfret fish are the main commodities in capture fisheries households in Depok Coast. However, if the occurrence of continuous arrests without further study is feared to cause the end of the sword and white pomfret fish resources in the future. This study aims to determine fisheries resources especially Sword and White Pomfret in Depok coast waters, with dynamic system models up to 2030. The method used in this research is the modeling of dynamic systems, where the sub-systems of the ecological, economic and associated social and serve as a model system dynamic of sword and white pomfret fish resources. Data for the ecological sub-system is an inventory of sword and white pomfret fish and the condition of the waters of Depok Coast. Furthermore, for the economic sub-system interviews were conducted by focus group discussion for the fishermen on Depok Coast and results in quantitative form. Data for the social sub-system is the number of fishermen and the population of Depok Village. The results of this modeling shows that overfishing can reduce sword and white pomfret fish resources if it is not compensated by fish preservation.

1. Introduction
These Fisheries system consists of a human system and a fisheries management system. The natural system consists of subsystems, namely fish, ecosystem, and biophysical environment [1]. The human system consists of four subsystems, namely fishers, harvest sector and consumer posts, fishing household and communities and economic / cultural environment. The management system is grouped into four subsystems, namely fishery policy and planning, fishery management, fishery development, and fishery research. The three components of the fishery system interact with each other to form a dynamic fisheries system.

The activities of fishermen in carrying out marine fisheries have various obstacles both from physical and non-physical factors. The constraints that many face in Indonesian fisheries and maritime affairs lie in their management systems. The potential of fisheries which is quite large but managed by people without the knowledge of fisheries conditions, is feared that overfishing will occur. The increasing...
exploitation of fish resources as a result of increasing demand for these resources will have an impact on the increasing pressure on the sustainability of fish resources [2]. Coupled with the nature of the use of marine resources, which in general are open access, which means that their utilization is open to anyone and their ownership is general so that the use of these resources tends to be free without any limitations as long as there are benefits/benefits obtained. The above conditions if it is not immediately managed (managed) properly, sooner or later it is feared that it will threaten the sustainability of fish resources. It is estimated that 47 percent of the world's fisheries resources have experienced full exploited, 19 percent were declared overexplored, 9 percent have been depleted. Thus 75 percent of fish resources have experienced critical [3].

Depok Coastal is the largest fishery products in Bantul Regency [4]. The potential for considerable marine resources in Depok Coast is a major factor in the progress of fisheries. High potential of marine resources in Depok Coast made many fishermen from outside Bantul Regency migrate to Depok Coast to find decent income for fish at there. According to data from TPI MinaBahari 45, the main commodity in Depok Coast are sword and white pomfret. In 2015, sword became the largest catch (32.42%) of the 13 types of fish available. Whereas white pomfret is the most expensive type of fish with the third largest catch result after Sword and Snapper. Therefore, the management of capture fisheries with characteristics of densely captured and multifunctional waters requires an integrated policy of coastal and marine natural resource utilization and management in order to be able to improve the welfare of fishing communities [5]. To make it happen, a resource management instrument is needed which focuses more on the ability of carrying capacity of the nature without ignoring the economic interests of the community. This study aims to determine fisheries resources, especially Sword and White Pomfret in Depok coast waters, with dynamic system models up to 2030.

2. Methods
This research was conducted in Depok coast, Bantul district using secondary data from TPI Mina Bahari 45. The model used was a dynamic system model using Powersim 8 software.

2.1. Production surplus model
This surplus production model is used to see carrying capacity and capture capabilities in fishery waters. This study uses a surplus model produced by Walters and Hilborn (1992) [6]. In general the regression form of the Walters and Hilborn production surplus model can be written as follows:

\[
Y = \alpha + \beta X_t + \gamma X_{tr} + \varepsilon_t
\]

\[
Y_t = \frac{U_{t+1}}{U_t} - 1
\]

\[
X_{1t} = U_t
\]

\[
X_{2t} = E_t
\]

\[
\varepsilon_t = \text{error term}
\]

Where :
K = Carrying capacity
q = capture ability
\(\alpha, \beta\) = coefficients of regression

Equation 1 is a regression equation with dependent or non-dependent variables is the rate of biomass change and independent or independent variables are CPUE and effort. Those equations can be used to estimate the biological parameters K (carrying capacity) and q (capture ability) separately from the three regression equation coefficients.
2.2. System dynamics model

Fisheries resources are dynamic natural resources, as well as pertubasi that occurs in these resources both in the form of a relationship between catch dam effort. Therefore the management of fisheries resources which are relatively dynamic and complex requires a dynamic analysis approach as well. For this reason, dynamic analysis needs to be done to see the interaction between the components of resources and their changes [7]. System Dynamics analysis is carried out through two stages, namely making a causal loop diagram and flow diagram. The causal loop diagram shows the relationship between variables in the system process being examined [8]. The basic principle of making it is a process as a cause that will produce a condition, or vice versa a situation as a cause will produce a process while a flow diagram is made based on the equation of the dynamic model which includes state variables (level), flow/rate, auxiliary, and constant.

\[ \text{Equation 2} \]
\[ \text{AME} = \frac{\sum (S_i - A_i)}{N} \]
\[ \text{Equation 3} \]
\[ S_I = \frac{\sum S_i}{N} \]
\[ A_I = \frac{\sum A_i}{N} \]

Where:
A = Actuall Value
S = Simulation Value
N = Time Unit

Equation 2 until 4 are validation between simulation and empirical data on model. Model can be declared valid if the deviation between the simulation results and actual data is <30% [10].
3. Results and discussion

3.1. Model for sword resources

Fishing data for Sword is obtained from Mina Bahari 45 fish auction. We got 54 months of historical data, that is from January 2014 until April 2018. In this 54 months, fishermen went to sea as many as 23,067 trips. Which means that the total effort of fishermen was 23,067 times. Figure 2 is that the highest sword catch is in 2017, which is 107,489.30 kg. While the lowest catch is in 2016, which is 13,273.98 kg. This is because there is a west monsoon that causes strong waves so that it is difficult to sail. The average sword catch per year is 46,395.18 kg. Results of the production surplus model to see carrying capacity and capture capabilities seen from CPUE data are 0.9986 and 0.9302. Then this value are included in the stock flow diagram for Sword Resources.

![Figure 2. Captured of Sword per Year 2014-2018](image)

![Figure 3. Stock Flow Diagram](image)
After the Stock Flow Diagram is made, the model is ready to be simulated. The simulation results in Figure 4 show that the stock of swords decreases every year. This is related to the decline in growth and also fish mortality, while the effort made by fishermen continues to increase each year. The fewer fish stocks there are, the less the number of catches obtained by fishermen. In 2030 the growth of sword fish was only 98 kg with a much higher death or capture rate of 105.45 kg and 273.78 kg, which would result in the depletion of sword resources on the coast of Depok.

Based on figure 5, we know that stock for sword fish will decrease during the simulation. This indicates that the sword fish will be depleted at a certain time. After the simulation is done, then the AME test is performed to determine the validity of the simulation results of the model and to find out whether the model can be predicted further. Results for AME test showed that the simulation results and acute data have a difference of 14.55% which means that the simulation results can be predicted further.

### 3.2. Model for white pomfret resources

The data for white pomfret is also obtained from TPI Mina Bahari 45. With 54 months, and total trips of fishermen went to sea as many as 23,067 trips. Data showed that average white pomfret catch per year is 9,501.92 kg (figure 8). The highest catch in 2015 with a total of 15,198.95 kg. Different from sword fish, in 2017, white pomfret actually got the lowest catch of only 3,569.40 kg. This could be because in that year, white pomfret was still migrating due to the existing high waves.

![Figure 4. Simulation results for sword resources](image)

**Figure 4. Simulation results for sword resources**

![Figure 5. Sword stock in model](image)

**Figure 5. Sword stock in model**
Results for the production surplus model to see carrying capacity and capture capabilities seen from CPUE data same as the results for sword fish are 0.9986 and 0.9302. It is just the difference is value of intrinsic growth / death for white pomfret, which is equal to 0.95 per year. Stock flow diagram for white pomfret is the same as that used for sword fish. The simulation results in Figure 9 showed that the stock of white pomfret decreases every year. This is related to the decline in growth and also fish mortality, while the effort made by fishermen continues to increase each year. The fewer fish stocks there are, the less the number of catches obtained by fishermen. In 2030 the growth of sword fish was only 50.63 kg, but this difference is not too far from the death rate of only 54.41 kg. But also, the number of arrests is far greater than the death of 83.27 kg.

After the simulation is done, result of AME test showed that the simulation results and acute data have a difference of 8.98%, which means that the simulation results can be predicted further. Figure 10 is value of AME in white pomfret model. Graphic showed for simulation white pomfret stock from 2014 until 2018- stable between 6000-8000 kg, but in reality stock of white pomfret has increased and decreased (fluctuated).

4. Discussion
In statistic data on the department of marine and fishiers, shows that on 2014 number of white pomfret is 6.910 and on 2015 is 6.597. This number not much different from the results of model. Same as white pomfret, the number of sword fish also have similarities between the department of marine and fishiers. The model shows, simulation results of white pomfret and word fish have increasing growth rate, but have decreasing stock.
5. Conclusion
The model shows that both sword fish and white pomfret will decline in stock until 2030. This is also followed by a lower growth rate than the death rate or catching rate. If this condition still continues, it...
will causes depletion of sword fish and white pomfret resources in the waters of Depok Coast. Therefore it is necessary for government efforts to provide a balance between the desires of the market and existing resources.

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