Bioeconomic Model of Threadfin Bream Fish Resources in Banten Bay Waters

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Abstract. Threadfin bream or Nemipterus sp. becomes one of the fish resources utilized in Banten Bay waters. The catch of threadfin bream decreased from year to year. Therefore, threadfin bream resources in the Banten Bay waters have alleged over-exploited. This study aims to analyze the optimum utilization of threadfin bream fish resources, seen from three management positions namely maximum sustainable yield (MSY), maximum economic yield (MEY) and open access equilibrium (OAE). Bio-economic analysis was carried out using the Gordon Schaefer model. Economic parameters that used in this research are price and fishing cost. Biological parameters are estimated using the Schaefer model. The set gillnet, Danish seine, and trammel net are the fishing gear for catching the threadfin bream in this research. The result shows that the maximum sustainable yield of threadfin bream is 1,344 tons/year and the optimum effort is 2,298 units/year. The productions rate of threadfin bream from 2007 continued to decrease until 2016. The highest economic profit was obtained in MEY of IDR 12.9 billion. The actual condition of threadfin bream fisheries is still under the condition of MEY management. The utilization of threadfin bream can still be optimized, but it needs to be done carefully and wisely so as not to cause damage to fish resources and the environment. The decrease in catch and CPUE needs to be aware of symptoms of overfishing.

1. Introduction
Threadfin bream or Nemipterus sp. becomes one of the fish resources utilized in Banten Bay waters. The catch of threadfin bream decreased from year to year. The decline in fish production is a serious problem that threatens the world community lately [1]. Therefore, threadfin bream resources in the Banten Bay waters have alleged over-exploited.

The problems in managing fish resources are actually divided into two main issues which are biological and economic problems. The biological problem is the sustainability of stock fish resources, while the economic problem is that the fishing effort has not provided optimum benefits for most fishermen. Therefore, in the utilization of threadfin bream fish resources is necessary to take into account these aspects.

Controlling of fishing intensity needs to be done in order to achieve maximum sustainable yield (MSY). On the other side, exploitation of fisheries resources must be able to provide optimum economic benefits for the people involved in the fisheries business. This study aimed to analyze the optimum utilization of threadfin bream fish resources, seen from three management positions which are maximum sustainable yield (MSY), maximum economic yield (MEY) and open access equilibrium (OAE).
Bio-economic analysis of the Gordon Schaefer model is one of the analyzes for exploitation of capture fisheries resources with an approach that combines economic forces that influence the fishing industry and biological factors that determine fish production and supply. Bio-economic analysis is intended to determine the maximum level of exploitation for fisheries.

2. Method
The research was conducted from April-November 2018 in Banten Bay waters. The primary data includes fish price and fishing cost come from interview process with fishermen. The published time series data (10 years) from government office were also collected includes type and number of fish production, type and number of fishing gear, and number of fishing trip.

The bio-economic model is estimated based on the biological model of Schaefer [2] and Gordon’s economic [3]. The bio-economic model is composed of models of biological parameters, fishing cost and fish prices. The utilization of threadfin bream fish resources is carried out with different fishing tools, namely set gillnet, boat seine and trammel net. So the standardization of fishing gear needs to be done before calculating the estimation of potential fish resources. The relationship of catches with fishing efforts was analyzed using the surplus production method with Schaefer model [4].

3. Result and Discussion
The production of threadfin bream in the waters of Banten Bay during the period 2007-2016 tends to fluctuate with a trend that continues to decline (Figure 1). The highest production of threadfin bream recorded in Karangantu PPN occurred in 2007 of 305 tons, but continued to decline until 2010 which production was 141.5 tons. From 2010 to 2013 production tends to be stagnant, and declined in 2014 to 2016. The decline in the production of threadfin bream not only happened in Banten Bay, but also occurred in the waters of the Sunda Straits, where from 2004 to 2013 experienced a downward trend in production [5].

The production volume of threadfin bream fisheries obtained from the Karangantu Fishing Port (KFP), recorded Danish seine fishing gear began operating in the waters of the Bay of Banten since 2010 (Table 1). However, based on information obtained from fishermen, before 2010 there had been Danish seine operating in the waters of Banten Bay. Threadfin bream in Banten Bay waters are generally caught with Danish seine. Threadfin bream are the target catch for Danish seine catches, generally along with goatfish, croackers and big eyes fish. Oktaviyani et al. [5] stated that threadfin bream is one of the most dominant demersal fish species caught with Danish seine.

Based on Table 1, all types of fishing gear tended to fluctuate with a downward trend. The highest number of set gillnet is in 2008 and the lowest is in 2015. The number of Danish seine has fluctuated since 2010 with the highest number in 2014 of 56 units, but then continued to decline. Similarly, the trammel net.

![Figure 1. Production of threadfin bream landed in Karangantu Fishing Port.](image-url)
The development of the number of fishing unit for capturing threadfin bream over past 10 years is tends to fluctuate with an upward trend. The operations of Danish seine in Banten Bay correlate with an increase in certain demersal fish production. But on one hand it causes other types of demersal fish continued to decrease in production.

The characteristics of threadfin bream fish, as demersal fish, is a type of fish that its life cycle mostly located at the bottom or around the bottom of the waters. So, it has limits of endurance to fishing pressure. The operation of Danish seine since 2010 is thought to have positive implication for the reduction in the amount of threadfin bream catch. Danish seine which operates in Banten Bay are commonly used to catch demersal fish, including threadfin bream fish. Although currently there is a prohibition on the use of Danish seine, it is still found operating. Based in interviews with fishermen in Karangantu, there has indeed been a decrease in the number and size of fish caught. This needs to be further research to support the sustainability of threadfin and demersal fish in Banten Bay waters.

The development of catch per unit effort (CPUE) during the 2007-2016 period tends to fluctuate with a downward trend. The highest CPUE occurred in 2007 and the lowest occurred in 2014. In 2015 the CPUE continued to increase until 2016 (as presented in Table 2). The capture effort used in the calculation of CPUE and maximum sustainable yield (MSY) is a standardized effort, with a standard fishing gear is the set gillnet. The MSY curve is presented in Figure 2.

The higher CPUE values reflect the level of efficiency in the use of the better effort and vice versa. The decline in CPUE value can also be caused by the availability of fish resources in nature continues to decline. If this condition continues, it will lead to over exploitation [6].

### Table 1. The number of fishing unit for capturing threadfin bream

| Year | Set gillnet | Danish Seine | Trammel Net |
|------|-------------|--------------|-------------|
| 2007 | 160         | -            | -           |
| 2008 | 168         | -            | -           |
| 2009 | 140         | -            | -           |
| 2010 | 122         | 44           | 43          |
| 2011 | 122         | 48           | -           |
| 2012 | 122         | 42           | 64          |
| 2013 | 125         | 44           | 82          |
| 2014 | 112         | 56           | 60          |
| 2015 | 118         | 40           | 40          |
| 2016 | 122         | 25           | 34          |

### Table 2. Value of CPUE during period of 2007-2016

| Year | Catch (kg) | Effort (unit) | CPUE (kg/unit) |
|------|------------|---------------|----------------|
| 2007 | 305,000    | 160           | 1,906.25       |
| 2008 | 285,000    | 168           | 1696.43        |
| 2009 | 205,000    | 140           | 1464.29        |
| 2010 | 141,500    | 1,698         | 83.33          |
| 2011 | 141,200    | 4,564         | 30.94          |
| 2012 | 139,000    | 4,130         | 33.66          |
| 2013 | 137,000    | 5,571         | 24.59          |
| 2014 | 115,300    | 5,611         | 20.55          |
| 2015 | 76,000     | 1,905         | 39.90          |
| 2016 | 69,000     | 882           | 78.23          |
The effort in Table 2 is the number of standardized fishing gear units, which in this case are set gillnet. The increasing of fishing effort in 2010 because Danish seine and trammel net started operating in Banten Bay waters, as presented in Table 1. The effort presented in Table 2 is the standard effort, with a standard fishing gear is the set gillnet. In the calculation of effort needs to be standardized because one of the requirement in analyzing is that each fishing gear according to its type has the same fishing ability [7]. Because of fishing power of Danish seine and trammel net much bigger that set gillnet, so that a high value is obtained in the calculation.

The approach used to estimate the potential yield of fish resources in a water area is to use data and information on catch per unit effort (CPUE) [8-1-0]. By determining the potential yield of fish resources, an appropriate policy can be determined for the future process of developing and managing the capture fisheries activities. The optimization concept used in this study is the bio-economic model, where capture fisheries activities are directed at achieving the highest level of sustainable production (MSY) and emphasizing not on achieving the highest level of production, but at the level of sustainable production that provides the highest efficiency (MEY) [11, 12].

The catch per unit effort (CPUE) is one of the stock abundance index and indicator of utilization status of fish resources and indicator of the sustainability of marine fisheries development. Obtaining an overview of the CPUE trends of a fishery can be one indicator of the health of a fishery. The increasing CPUE trend will be an illustration that the level of exploitation of fish resources can be developed. The horizontal CPUE catch is describing that the rate of exploitation of fish resources is approaching the saturation of efforts. The declining trend of catch per unit of effort is an indication that the level of exploitation of fish resources if left unchecked will lead to a situation called over exploitation [13].

The value of CPUE reflected the number of capture strategies related to the choice of fishing ground, habitat type and fishing techniques, even with the same number of fishing trips [14, 15]. The changes of CPUE value can be caused by the differences in distribution number of effort in particular season or area, the presence of other fishing gear and the ability and habits of fishing [16, 17]. The maximum sustainable yield of threadfin bream in the Banten Bay in 2016 reached 1,344 tons / year and F_MSY of 2,298 units / year. The production of threadfin bream fish from 2007 to 2016 has not exceeded the MSY point. However, the amount of effort exceeded F_MSY in 2011 to 2014 (Figure 2). From the analysis, the coefficient of determination by 0.52, this means the variable number of fishing gear can affect the CPUE variable by 52%, while the rest is influenced by other variables. The value of correlation coefficient of 0.72 which indicates that the CPUE and effort have a high or strong closeness (correlation) value. The results of the bio-economic calculation of the threadfin bream fisheries are presented in Table 3.

![Figure 2](image.png)

**Figure 2.** The relationship of catch and effort of threadfin bream in Banten Bay.
The actual production in 2016 is still below the MSY value. However, based on the production trends and CPUE which has continued to decline over the past 10 years, there are indications that there have been symptoms of overfishing of threadfin bream fish. In addition, there are fishing activities that are not landed at the fishing port, or not reported, so there are weaknesses in fisheries data collection. The other indication is an increase in the number of other fish production that continues to increase, such as pony fish, which can indicate the present of certain fish blooming and a decrease in other types of fish, including the threadfin bream fish. The production of pony fish in 2016 reached 502 tons and is the largest catch (25%), meanwhile the threadfin bream is only 3.4%. Production of pony fish has continued to increase since 2012-2016 [18]. Therefore, it is necessary to do further research on threadfin bream fish in the Banten Bay waters.

| Table 3. Bio-economic optimization in each management positions |
|-----------------|-----------------|-----------------|-----------------|-----------------|
| Variable        | Actual          | MSY             | MEY             | OAE             |
| Catch (kg)      | 69,000          | 1,344,051       | 1,343,658       | 90,346          |
| Effort (Unit)   | 882             | 2,298           | 2,259           | 4,517           |
| Revenue (IDR)   | 690,000,000     | 13,440,506,020  | 13,436,577,20   | 903,460,212     |
| Cost (IDR)      | 176,400,000     | 459,587,730     | 451,730,106     | 903,460,212     |
| Profit (IDR)    | 513,600,000     | 12,980,918,290  | 12,984,847,10   | 2               |

The maximum production at the MEY level of 1,343 tons / year, as presented in Table 3, was reached before the maximum sustainable yield (MSY) production level of 1,344 tons / year. The number of optimum fishing effort in MEY (E_{MEY}) condition is 2,259 units, where the number is still below the optimal fishing effort needed to produce maximum sustainable fish production of 2,298 units (E_{MSY}). This means that any fishing effort at the MEY level is more efficient than fishing effort at the MSY level, so that the rent or economic profit under the MEY condition is greater than the rent at the MSY condition.

The assumptions used in making this Gordon Schaefer model are the price of fish is the average fish price, the cost per unit of effort is considered constant (in this case is the average fishing cost of set gillnet as a standard fishing gear). The price of fish ranges from IDR 5,000-15,000 and the fishing cost range from IDR 150,000-250,000. Fauzi [19] stated that the use of these measurement is important in economic principles because in economics, the measurement of indicators through changes and averages is far better than absolute measurement.

The decline in catch, economically, will reduce the overall profitability of fishermen's businesses, because the revenue obtained is not proportional to the costs incurred. Loss of profits derived from the use of fisheries resources can also be caused by the large cost of fishing per effort. With the high cost of catching the profits will be reduced, even though the catch has not yet passed the MSY level.

4. Conclusion
The optimal production of threadfin bream at maximum sustainable yield (C_{MSY}) of 1,344 tons/year and the optimum effort (E_{MSY}) of 2,298 units/year. The optimum production at MEY (C_{MEY}) of 1,343 tons/year and the optimum effort (E_{MEY}) of 2,259 units/year. The optimum production at OAE (C_{OAE}) of 90 tons/year and the optimum effort (E_{OAE}) of 4,517 units/year. The highest economic profit was obtained in MEY of IDR 12.9 billion. The production rate of threadfin bream from 2007 continued to decrease until 2016. The decrease in catch and CPUE needs to be aware of symptoms of overfishing.

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