BIOECONOMIC ANALYSIS OF THE BIG EYE TUNA FISHING (Thunnus obesus) LANDED AT CILACAP OCEAN FISHING PORT

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Abstract

Thunnus obesus catchment in Cilacap has been carried out for years due to its abundant availability of resources as well as to meet both local and international market demands. Increasing market demand may result in growing exploitation that affects biological conditions and Thunnus obesus business sustainability over long terms. The purpose of this study was to determine the sustainable potential and economic value of Thunnus obesus utilization in the Indian Ocean of WPPNRI 573 to improve sustainable fisheries management and obtain optimal economic benefits. Calculation of Catch per Unit Effort (CPUE) is used as an indicator of effort utilization technique efficiency level. CPUE value was further analyzed using the Gordon Schaefer bioeconomic model including MSY, MEY and OAE, in obtaining some information on utilization rate and effort level. The results show that the CPUE average value of 2016-2021 periods was 1.989 kg/unit. In MSY conditions, the value of CMSY and EMSY are 1,358,743 kg and 1,022 units of fishing gear/year within a profit of IDR 42,446,885.88. During MEY conditions, the CMEY value was 1,337,312 kg and the EMEY value was 894 fishing gear/year within a total profit of IDR 43,340,952.91. In OAE conditions, the COAE value is 596.849 kg / year, EOAE is 1.788 units of fishing gear/year within its fishing effort is at the break-even point (not profitable and not detrimental). The analysis illustrates that the resource utilization level of Thunnus obesus has been moderately exploited with an average utilization rate of 68% and an average effort level of 50%.

Keywords: MSY, MEY, OAE, Utilization Rate, Effort Level, Thunnus obesus.

Introduction

The vast sea area of Indonesia has great potential for marine and fishery resources. According to(Muawanah et al., 2021),Indonesia is one of the largest tuna producers in the world, contributing 16% to world tuna production. Indonesia is an archipelagic country with enormous fishery business potential due to the many species of fish(Hutajulu et al., 2023). The dominant tuna species caught in Indonesia are Albacore Tuna (Thunnus alalunga), Yellowfin Tuna (T. albacares), Big Eye Tuna (T. obesus) and Southern Bluefin Tuna (T. maccoyii). One of the fishery resources that has high potential is bigeye tuna with a maximum sustainable yield (Maximum Sustainable Yield) estimated at 87,000 tons per year in accordance with the Decree of the Minister of Maritime Affairs and Fisheries of the Republic of Indonesia Number 121 of 2021 concerning Management Plans for Tuna, Cakalang, Fisheries. and Cobs. The total production of all IOTC member countries in 2018 was 93,515 tonnes and the average production (2014-2018) was 92,140 tonnes/year with the utilization rate of bigeye tuna in 2019 not being overfished but subject to overfishing.

Tuna is distributed throughout the oceans and has a wide cruising range to pass through the EEZ sea(Duarte-Neto et al., 2012) (Tambunan, 2021). Bigeye tuna has great potential as a high-value fishery resource. Tuna is a high primary species that has important economic value and is spread in almost all areas in Indonesian waters(Made et al., 2017; Suyasa et al., 2020). Bigeye tuna has a high economic value in the global market, especially in Asian and European countries. This is because bigeye tuna has delicious meat and is high in protein, so it is the main raw material in the food and beverage industry. Bigeye tuna can be cultivated intensively in several countries such as Japan, Australia and the United States. This potential is an opportunity to increase tuna production in a sustainable manner and reduce pressure on natural tuna stocks. Bigeye tuna plays an important role in the lives of coastal communities who depend on fisheries for their livelihoods. Increased production of bigeye tuna can have a positive impact on the welfare of coastal communities. However, It should be noted that overfishing of bigeye tuna can threaten the sustainability of this fish population. Therefore, it is necessary to manage fisheries resources in a sustainable manner to ensure that the potential of bigeye tuna can be utilized optimally without sacrificing environmental sustainability.

Utilizing the potential of large pelagic fisheries in WPPNRI 573 which landed at PPS Cilacap has a great opportunity to drive the fisheries economy in Cilacap Regency and encourage an increase in national economic value in the fisheries sector. Cilacap Regency contributes a higher contribution to marine fishery production compared to other cities in Central Java province. One of the captured fisheries commodities landed at PPS Cilacap is bigeye tuna (Thunnus obesus). Bigeye tuna production in the last period of 2016 – 2021 fluctuated with the highest production in 2021 of 2,585.02 tons in frozen and fresh forms. 5% of the marketing of tuna and similar production is absorbed by the local market in Central Java, 15% to West Java, 30% to East Java and 50% to Jakarta.

The business of catching bigeye tuna (Thunnus obesus) continues to increase along with the increasing demand for commodity products for bigeye tuna (Thunnus obesus) both locally and internationally. This encourages an increase in exploitation efforts that have the potential to affect biological conditions and the sustainability of the bigeye tuna (Thunnus obesus) fishing business. According to(Sri Lestari et al., 2016)p.sThe increase in tuna production is influenced byfuel, ship size, engine power, and length of trip.The sustainability of the fishing business for bigeye tuna (Thunnus obesus) needs to be studied further both in terms of biology and economics using the bioeconomic model of Gordon Schaefer to determine the value of Maximum Sustainable Yield (MSY), Maximum Economic Yield (MEY), Open Access Equilibrium (OAE) in order to obtain information on utilization rate and effort level.

2. Materials and Methods

Methods in analyzing the bioeconomics of bigeye tuna (Thunnus obesus) fisheries using Gordon Schaefer. Variable data were analyzed using the Gordon-Schaefer bioeconomic model(Dian Munica et al., 2016; Mohamad Erwin Wiguna & Rufina Agustin Yuarsa, 2018; Zulbainarni et al., 2011). The CPUE calculation aims to determine the abundance and utilization rate of the eye fishbig*(Thunnus obesus)*which is based on the division between the total catch (catch) and effort (effort).CPUE analysis is used to determine the abundance of bigeye tuna (Thunnus obesus) from the total production (catch) per number of vessels carrying out catch unloading (effort) at PPS Cilacap in the 2016 – 2021 period. If the CPUE trend rises, it indicates the level of exploitation. fish resources are developing and if the CPUE trend is decreasing it shows that the level of exploitation is already leading to overfishing if it continues(Mohamad Adha Akbar et al., 2016). Bigeye tuna (Thunnus obesus) in PPS Cilacap comes from fishing using tuna handlines and longlines. The catching abilities of handline and longline tuna are not the same, therefore it is necessary to standardize fishing effort. According toHerka Mayu et al. (2018)the formula for standardizing fishing effort is to use the fishing power index by calculating the effort to standardize fishing gear.

Fisheries bioeconomics is a combination of biological and economic disciplines in the field of fisheries, where the basic model is based on biological theories and concepts which are then combined with economic concepts to optimize the utilization of fisheries biological resources based on an economic perspective. The bioeconomic analysis used is the Gordon Schaefer Bioeconomics model, which is a way of managing fisheries so that they remain sustainable and can obtain optimum economic benefits by paying attention to the relationship between efforts to capture fish resources which can be seen from biological and economic aspects using production time series data and effort.(Noordiningroom et al., 2012).

Table 1. Bioeconomic Model of Gordon Schaefer

	MSY	**MEY**	**OAE**
Catch (C)	α/4β	αEMEY – β(EMEY)2	αEOAE – β(EOAE)2
Capture effort (E)	α/2β	(pα – c) / (2pβ)	(pα – c) / (pβ)
Total revenue (TR)	CMSY . P	CMEY . P	COAEs . P
Total expenses (TC)	c. EMSY	c. EMEY	c. EOAE
Profit(π)	TRMSY - TCMSY	TRMEY - TCMEY	TROAE – TCOAE

3. Results and Discussion

Bioeconomic analysis of bigeye tuna (Thunnus obesus) fisheries

Table 2. Parameters

a	2658,252659
b	1.300155526
***price*(p)**	41,719
***cost*(c)**	13,927,644
p*a	110898641.6
(p*a)-c	96,970,997
p*b	54240,69877
2(pb)	108481,3975
a^2	7066307,2
2b	2.600311052
4b	5.200622105

Table 3. The bioeconomic analysis of the Gordon Schaefer model

	MSY	**MEY**	**OAE**
C (Kg/ Year)	1,358,743	1,337,312	596,849
E (Unit/ Year)	1,022	894	1,788
TR (Rp/ year)	IDR 56,684,874,049	IDR 55,790,807,023	IDR 24,899,708,229
TC (Rp/ Year)	IDR 14,237,988,166	IDR 12,449,854,114	IDR 24,899,708,229
π(Gain)	IDR 42,446,885,883	IDR 43,340,952,909	Rp0

Bioeconomic analysis with Gordon Schaefer is one method to understand the relationship between the sustainability of fishery resources and the resulting economic value. This method combines economic theory and fisheries science in identifying the sustainability of fishery resources and maximizing the economic value that can be generated. Gordon Schaefer's approach to bioeconomic analysis is based on the Hubbert-Schaefer model, which assumes that the sustainability of fishery resources depends on production levels that can be maintained consistently at a certain level. In this model, optimal production levels can be achieved by considering sustainable catch rates, operating costs and market prices.

In bioeconomic analysis with Gordon Schaefer, there are several factors to consider, including:

1. Fish biology: Fish biology factors, such as growth rate, reproduction rate, and fish population size, greatly affect the sustainability of fishery resources.
2. Fishing technology: Fishing technology, such as nets and lines, can affect catch rates and operational cost efficiency.
3. Market prices: Market prices can affect the economic value generated from fishery resources.
4. Operational costs: Operational costs, such as fuel and labor costs, affect the operational efficiency and profitability of fishers.

In practice, bioeconomic analysis with Gordon Schaefer can assist the government and fishermen in optimizing fish production and the resulting economic value. This can be achieved by optimizing sustainable catch levels, considering fish biology and operational cost efficiency, and managing the market by paying attention to price and demand. Bioeconomic analysis of bigeye tuna (Thunnus obesus) at PPS Cilacap using the Gordon Schaefer model achieved an MSY condition at catch condition (CMSY) of 1,358,743 kg/year and an Effort value (EMSY) of 1,022 units of fishing gear/year with a profit of Rp. . 42,446,885,883. The Maximum Economic Yield (MEY) condition is obtained when the Catch value (CMEY) is 1,337,312 kg/year and the Effort value (EMEY) is 894 units of fishing gear/year with a profit of Rp. 43,340,952,909. The OAE condition in the Catch state (COAE) is 596,849 kg/year and the Effort value (EOAE) is 1,788 units of fishing gear/year with a profit of 0. The graph of the bioeconomic balance point of the Gordon Schaefer model can be seen in the graph below:

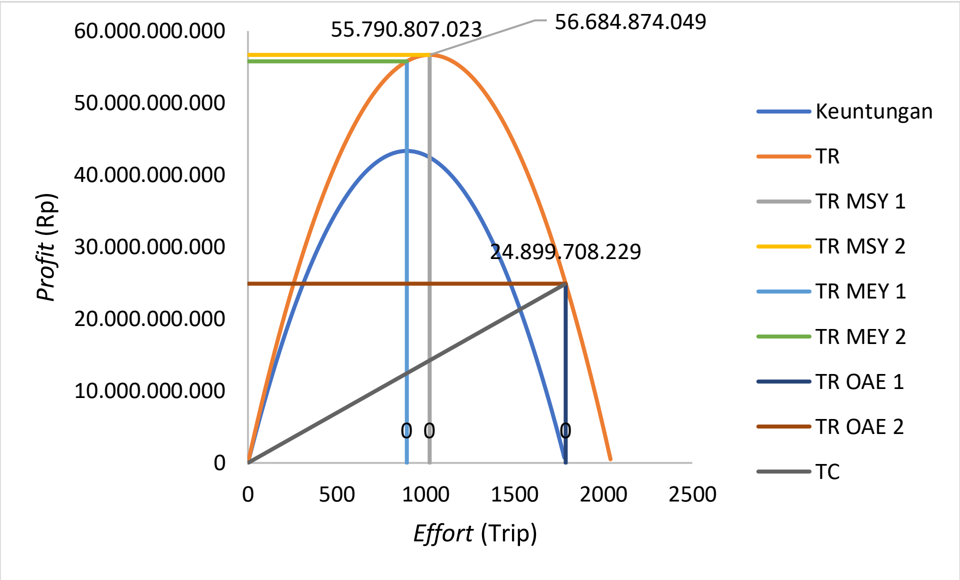

Figure 1. MEY Big Eye Tuna

Based on the graph above, it can be seen that the TRMSY condition is greater than TRMEY and TCMSY is greater than TCMEY. The Maximum Economic Yield (MEY) point is the optimal point when the MEY condition produces a lot of production, but less fishing effort is made compared to the MSY condition so that it is able to get a large income and the profits are greater. The profit obtained in the Maximum Economic Yield (MEY) condition is Rp. 43,340,952,909 while the profit in the MSY condition is Rp. 42,446,885,883. This shows that when conditions of Maximum Economic Yield (MEY) business profits for fishing for bigeye tuna (Thunnus obesus) are at their maximum.

Maximum Economic Yield (MEY) is a condition in which the profits of the fishing business reach the maximum point that can be obtained from the fishing. Under MEY conditions, the catch rate for bigeye tuna is carried out by considering various factors, such as operational costs, selling prices, and available fish stocks. However, to achieve MEY conditions in catching bigeye tuna, good and sustainable management efforts are needed so that fish stocks are maintained and do not experience a significant decline. MEY conditions can also be affected by fluctuations in market prices and operational costs which may change from time to time.

In addition, MEY conditions also need to be taken into account by considering the environmental impact of fishing, such as the effect on marine ecosystems and the sustainability of fish stocks in the future. Oceanographic factors can be indicators in determining the potential of fishing areas(Dewi et al., 2023). Based on the distribution of bigeye tuna fishing areas in the Indian Ocean, it was explained that bigeye tuna were caught in the range of SST, chlorophyll-a and SSHA 25-30°C, 0.10-0.71 mg/m3 and -0.14-0 .16m(Bakar Sambah et al., 2017).Based on research(Adnal Yeka et al., 2022),mentioned that there is a significant effect between chlorophyll-a and skipjack tuna. The vertical distribution characteristics of tuna are related to individual size, and smaller individuals are dispersed in shallower layers of water(Thierry Nyatchouba Nsangue Corresp et al., 2018). This phenomenon has been reported in tests tracking archival markers such as bigeye tuna(Schaefer et al., 2007).Therefore, sustainable and responsible fisheries management efforts are very important in achieving MEY conditions and maintaining the sustainability of the bigeye tuna fishing business.

Production of bigeye tuna will increase to the peak point of MSY, which is 1,358,743 kg, but if the effort has exceeded the MSY effort, namely 1,022 units of fishing gear/year, production of bigeye tuna will decrease to point 0. The peak of profit is at the peak point of MEY, namely Rp. 43,340,952,909 but if the effort value exceeds the MEY effort value, namely 894 units of fishing gear/year, the profit will decrease. Spawning season for bigeye tuna in the Indian Ocean is thought to occur in October(Ria Faizah & Budi Iskandar Prisantoso, 2010).

The level of utilization of bigeye tuna depends on various factors, such as market demand, availability of fish in nature, and management efforts undertaken by the authorities. Bigeye tuna is a very popular fish in the international market because of its delicious meat and good texture for processing into various dishes, such as sushi and sashimi. This high demand has led to overfishing of bigeye tuna, resulting in a significant decline in populations of this fish. Authorities, such as regional fisheries organizations and national fisheries management, have made various efforts to manage bigeye tuna populations and limit fishing for this fish, such as by setting catch quotas, tightening catch regulations, and encouraging more sustainable fishing practices. However, even though management efforts have been made, the level of utilization of bigeye tuna is still relatively high, so it is necessary to continue to make more serious and sustainable efforts so that this fish population can recover and fisheries management can be more sustainable. Managing fisheries to meet social, economic and ecological goals is a fundamental issue faced in fisheries management worldwide(Farmery et al., 2019). In fisheries management, arrangements regarding access and allocation of fishing quotas often raise issues of fairness, fairness and equity(McShane et al., 2021). A key challenge for fisheries managers is to be able to anticipate how fishing effort will be reallocated after management such as permanent or seasonal closures of fishing grounds(Girardin et al., 2015). The United Nations has identified access to and benefits from fisheries resources as a key challenge for sustainable development(Parlee et al., 2021). In fisheries management, the primary focus has been on the sustainability of the target species and, in recent decades, on profitability. However, multi-objective management is now important because fisheries have been recognized as complex socio-ecological systems. Policies and laws demand a move towards a quantitative approach to reconcile multiple objectives and operationalize them in harvest strategies(Dowling et al., 2020). Several development goals involve sustainable management of fisheries given environmental, economic, and social uncertainties. The response of fish populations to variability in the marine environment has implications for decision-making processes related to resource management. There remains considerable uncertainty in estimating the response of tuna populations to short to medium term variability and long term changes in the marine environment(Dowling et al., 2020). Several countries have developed tools to assist fisheries managers and government agencies in engaging the social dimensions of industry and community welfare in fisheries management, such as Australia(Marentette & Zhang, 2022).Australia is considered a world leader in sustainable fisheries management(Fleming et al., 2020).

4. Conclusion

Based on the results of Gordon Schaefer's bioeconomic analysis, it is known that the level of resource utilization for bigeye tuna (Thunnus obesus) is not overfished but subject to overfishing with an average of 68% and the level of effort for bigeye tuna (Thunnus obesus)average 50%.

Based on the conclusions obtained, the advice that can be given is to establish a management policy for the bigeye tuna (Thunnus obesus) fisheries, limiting the number of fishing attempts, must be supported by clear rules or regulations and supervision from all related parties. So that fishermen and stakeholders get optimum benefits, are economically efficient and resources remain sustainable.

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