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THE ECONOMIC ANALYSIS OF FISHERIES MANAGEMENT OF BIG PELAGIC FISH IN WPPNRI 715

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ABSTRACT

Fisheries management is essential in striving for fish resources to be utilized optimally and sustainably and have a welfare impact. WPPNRI 715 is one of Indonesia's eleven fisheries management areas with the most significant potential in big pelagic fish with high economic value. The aim of this study was to estimate the economic value in the management of large pelagic fisheries in WPPNRI 715. The result of the research can show utilization of big pelagic fish in WPPNRI 715 is good condition and has not exceeded the Maximum Sustainable Yield (MSY) value. Additionally, economically the benefits are still in good condition. The optimal production (MSY) of big pelagic fish in WPPNRI 715 is 421 872, 11 tons. Maximum profit MEY is Rp3 065 588,97 trillion with the actual effort of 470 609 trips where optimal effort is sustainable (MSY) of 861 131 trips and economically optimal effort (MEY) of 554 902 trips. Based on the results of the study, it was stated that there were economic benefits in the utilization of large pelagic fish resources in WPPNRI 715.
Keywords: Big pelagic fish, economic value, fisheries management, maximum sustainable yield

Analisis Ekonomi Pengelolaan Perikanan Ikan Pelagis Besar di WPPNRI 715

ABSTRAK

Pengelolaan perikanan merupakan aspek penting dalam mengupayakan sumberdaya ikan untuk dapat dimanfaatkan secara optimal, berkelanjutan dan memberikan dampak terhadap kesejahteraan. WPPNRI 715 merupakan salah satu dari sebelas wilayah pengelolaan perikanan di Indonesia dengan potensi terbesar adalah ikan pelagis besar yang memiliki nilai ekonomis tinggi dibandingkan kelompok ikan lainnya. Tujuan dari penelitian ini untuk menduga nilai ekonomi dalam pengelolaan perikanan pelagis besar pada WPPNRI 715. Hasil penelitian menunjukkan bahwa tingkat pemanfaatan sumberdaya ikan pelagis besar pada WPPNRI 715 berada pada kondisi baik dan belum melebihi nilai MSY, selain itu juga secara ekonomi keuntungan pemanfaatan sumberdaya ikan pelagis besar di WPPNRI 715 masih dalam kondisi baik. Optimal produksi ikan pelagis besar pada WPPNRI 715 (MSY) yaitu sebesar 421 872,11 ton. Rente maksimum (MEY) sebesar Rp3 065 588,97 trilyun, produksi aktual sebesar 320 444,42 ton dengan effort aktual sebanyak 470 609 trip dimana effort optimal lestari (MSY) sebanyak 861 131 trip dan effort optimal secara ekonomi sebanyak 554 902 trip. Hasil penelitian menyebutkan bahwa terdapat keuntungan ekonomi dalam pemanfaatan sumberdaya ikan pelagis besar di WPPNRI 715.
Kata Kunci: *ikan pelagis besar, maximum sustainable yield, nilai ekonomi, pengelolaan perikanan*

INTRODUCTION

The availability of fishery resources in Indonesian waters has potential economic value and is a source of economic strength for the community, especially coastal communities. However, the utilization of fishery resources is not only oriented towards increasing production and economic aspects, but also oriented to the preservation of fishery resources itself, so that the availability of resources can continue to exist in a sustainable manner. This is in line with the mandate of Law Number 45 of 2009 Article 6 paragraph 1 which emphasizes that fisheries management is at achieving optimal and sustainable benefits, and ensuring the sustainability of fishery resources (Ma'mun *et al.,* 2017; Utami *et al.,* 2020).

Indonesian fisheries management is mandated in one of the work programs of the Ministry of Maritime Affairs and Fisheries of the Republic of Indonesia through the establishment of a fishery management area with a fishery management territorial system legalized by the government through the Minister of Marine Affairs and Fisheries Regulation Number 18/PERMEN-KP/2014 concerning Fishery Management Areas. WPPNRI 715 is one of eleven fisheries management areas covering 6 (six) provincial administrative areas covering North Sulawesi Province, Gorontalo Province, Central Sulawesi Province, Maluku Province, North Maluku Province, West Papua Province and territorial waters covering Tomini Bay, Maluku Sea, Halmahera Sea, Seram Sea and Berau Bay (Papua). The considerable potential of fish resources in WPPNRI 715 impacts exploitation, over-exploitation and theft of fish.

Fishery management is grounded in the principle that resource utilization should be aligned with the ecosystem's capacity and carrying capacity. The problems of using fishery resources in WPPNRI 715, such as overfishing conditions, conflicts between fishers, environmental damage such as pollution and rampant IUU fishing, require fishery resource management to solve and overcome all problems related to the fisheries sector to realize sustainable management of fish resources and their habitats with optimal utilization for achieving sovereignty, sustainability and prosperity (Purwanto and Mardiani, 2020).

Fishery production in WPPNRI 715 based on fisheries statistics by fisheries management area for 2005-2016 Ministry of Maritime Affairs and Fisheries shows that the most significant fishery production is sizeable pelagic fish. The catch for large pelagic fish shows a reasonably large number compared to other types of fish, and this shows that sizeable pelagic fish species dominate the potential fish resources in WPPNRI 715 (PerDirJen PT No. 17/PERDJPT/2017). Complex problems in the management of large pelagic fisheries in WPPNRI 715 include how the optimum level of production of large pelagic fisheries is biologically and economically and how much is the estimated cost of managing large pelagic fisheries that must be budgeted at WPPNRI 715 must be resolved with the establishment of an appropriate fisheries policy. So it is necessary to analyze the economics of fisheries management in WPPNRI 715 to create appropriate policies for optimal and sustainable results in realizing prosperity.

METHODOLOGY

Research Method

The method used in this research is a case study method (case study). The multi-stage sampling method is carried out with the stages of determining the respondent sample at each point, distinguished by fishing vessels and fishing gear. Fishing vessels used and the size of large pelagic fishing vessels in WPPNRI 715, with each group of respondents having a minimum of 30 respondents determined according to the research objectives.

Location and Time of Research

Location of research was conducted in WPPNRI 715, with the research location determined by the most significant number of large pelagic fish catches and the completeness of the research data, namely in two provinces, including North Sulawesi Province and DKI Jakarta Province. The research lasted for nine months, starting from December 2018 to August 2019, which consisted of several stages starting with the research preparation stage in the form of preparing research proposals, making questionnaires, field observations, collecting primary and secondary data to the stage of data processing, modelling and verification.

Types and Source of Data

Types and sources of data used in this research are primary and secondary. Primary data sources were obtained by giving questionnaires, interviews, focus group discussions (FGD) and direct observation of research on conditions and phenomena in managing large pelagic fish fisheries in WPPNRI 715. For secondary data, collecting was carried out from various related fisheries institutions, namely: Fisheries Statistics According to WPPNRI 2005-2016 Ministry of Maritime Affairs and Fisheries, Central Statistics Agency, Marine and Fishery Service, Fishery Port Data 2011-2018, the literature review involves gathering data and information from relevant sources pertaining to the management of large pelagic fish fisheries within WPPNRI 715.

Data Analysis Methods

Bioeconomic models are the basis for researchers to analyze data by estimating the amount of captured fisheries resources that can be utilized. The surplus production model estimated the biological parameters of sizeable pelagic fish resources in WPPNRI 715. Fishery production is expressed in Clark's (1985) function:

$$h = qxE$$

Where, h is a production; q *is* fishing power coefficient; x is a fish stock; and E is a fishing *effort (effort).*

A standard calculation of fishing gear is carried out to determine the amount of effort (effort). Standardization is carried out to determine the fishing gear that is used as a standard for calculating effort standard, the formula for standardizing fishing effort (Gulland, 1983):

$$FPI = \frac{CPUEi}{CPUEs}$$

Thus:

$$f_s = FPI x f_i$$

Where, the FPI is a fishing power index; $CPUEi$ is $CPUE$ of standardized fishing gear; $CPUEs$ is a $CPUE$ of standard fishing gear; f_s is fishing effort standardized results; and f_i is a fishing effort to be standardized.

Optimal fishing effort to obtain Maximum Economic Yield (MEY) model Schaefer bioeconomy are carried out using the fox algorithm approach (Fauzi, 2010):

$$MEY = r\frac{K}{4}\left(\frac{c}{2p}\right)^2 (\frac{r}{q^2}K)$$

The economic rent from the use of considerable pelagic fish resources in WPPNRI 715 is written in the following equation:

$$\begin{aligned} \pi &= TR - TC \\ &= p(aE - bE^2) - cE \end{aligned}$$

Calculation of operational cost pelagic fish fisheries management in WPPNRI 715 in Purwanto (2015), as follows:

$$BPi = \frac{V_i}{V_f} * BPt$$

$$V_f = \sum_{i=1}^{f} Vi$$

Where, the *BPi* is the cost of extensive pelagic fishery management in WPP 715; *Vi* is the production value of large pelagic fish in WPP 715; *Vf* is a production value of large pelagic fish in WPP 715; and *BPt* is a relative value of sizeable pelagic fish production in WPP 715.

RESULTS AND DISCUSSION

Parameter Estimation

Biological parameters in a sizeable pelagic fishery in WPPNRI 715 were calculated using a surplus production model where more than one fishing gear used (multi-gear) with sizeable pelagic fish catches more than one type of fish (multi-species), namely purse seine, huhate (pole in line), handline, longline tuna and oceanic gill nets. Calculation of the estimation of biotechnical parameters for large pelagic fishery resources of WPPNRI 715 using catch per unit effort (CPUE), where the production of large pelagic fish catches per fishing gear is divided by the effort per fishing gear based on available secondary data. According to Fauzi (2010), explaining that catch per unit effort (CPUE) is a method used to determine the average annual yield of marine fishery production so that fishery production in a fishing area will be known whether there is an increase or decrease in production. Added by Sant'Ana *et al.* (2017) The catch per unit of fishing effort (CPUE), reflects the comparison between the catch and the unit effort. Calculate the catch per unit effort (CPUE) for each fishing gear, which can be seen in Table 1.

Based on data on catching large pelagic fish at WPPNRI 715, the productivity value of purse seine fishing gear has the highest average compared to other fishing gear, so the purse seine gear becomes the standard fishing gear which has an FPI value equal to one (= 1). In contrast, the FPI value for other fishing gear is obtained from the CPUE value of other fishing gear divided by the CPUE value of the fishing gear used as the standard. It can be seen in Table 2.

Each large pelagic fishing gear in WPPNRI 715, both purse seine, *huhate* (pole in line), handline, longline tuna and oceanic gill nets, have different abilities in catching sizeable pelagic fish in WPPNRI 715, for that standardization is needed fishing gear by calculating the fishing power index (FPI) in standardizing large pelagic fishing gear in WPPNRI 715. According to Octoriani *et al.* (2016) the fishing power index (FPI) is one of the calculations in standardizing fishing gear by homogenizing the value of fishing effort (effort standard).

Table 1. CPUE Per Fishing Gear at WPPNRI 715 in 2011-2018

Year	*Catch Per Unit Effort* (CPUE) *ton/trip*				
	Pukat cincin (purse seine)	*Huhate* (pole in line)	handline	longline tuna	Ocean gill nets
2011	0.8031	1.0060	0.0104	0.4421	0.0780
2012	0.7167	0.2263	0.0442	0.1026	0.0684
2013	1.0129	0.3695	0.0169	0.3691	0.0631
2014	0.6815	0.7845	0.0298	0.4015	0.1206
2015	0.5810	1.0664	0.0263	0.0498	0.0786
2016	0.6179	0.2160	0.0200	0.2728	0.0995
2017	0.6466	0.2311	0.0204	0.3144	0.0001
2018	0.6368	0.2258	0.0205	0.2729	0.0995
Total	5.6966	4.1254	0.1886	2.2252	0.6076
Average	0.7121	0.5157	0.0236	0.2782	0.0759

Source: Data Analysis, 2019.

Table 2. FPI Per Fishing Gear at WPPNRI 715 in 2011-2018

Year	Fishing Power Index (FPI)				
	Pukat cincin (purse seine)	*Huhate* (pole in line)	handline	longline tuna	Ocean gill nets
2011	1	1.25	0.01	0.55	0.09
2012	1	0.32	0.06	0.14	0.09
2013	1	0.37	0.02	0.36	0.06
2014	1	1.15	0.04	0.58	0.17
2015	1	1.84	0.05	0.86	0.13
2016	1	0.35	0.03	0.44	0.16
2017	1	0.36	0.03	0.48	0.00
2018	1	0.36	0.03	0.42	0.16

Source: Data Analysis, 2019.

Table 3. Value of effort standard per Fishing Gear in WPPNRI 715, periode 2011-2018

Year	Standard Value of Fishing Equipment (effort standard)				
	Pukat cincin (purse seine)	*Huhate* (pole in line)	handline	longline tuna	Ocean gill nets
2011	39,052	69,697	105,681	17,983	39,035
2012	55,085	71,838	181,107	20,644	57,606
2013	43,553	45,311	156,671	11,289	31,911
2014	82,775	52,286	136,805	19,807	45,557
2015	147,551	70,663	206,829	16,742	60,700
2016	192,603	92,643	236,007	27,719	93,365
2017	229,567	115,773	290,899	32,428	64
2018	199,293	97,867	248,231	27,996	94,239

Source: Data Analysis, 2019.

Table 4. Calculation Results for Total Production, Standard Effort and Standard CPUE

Year	Total Production (tons)	Standar *Effort* (trip)	CPUEs (tons/trip)
2011	217,997	271,447	0.80
2012	276,865	386,281	0.72
2013	292,472	288,736	1.01
2014	229,828	337,230	0.68
2015	291,954	502,486	0.58
2016	396,923	642,338	0.62
2017	432,365	668,730	0.65
2018	425,151	667,626	0.64
Total	2,563,555	3,764,872	5.70
Average	320,444,42	470,609,05	0.71

Source: Data Analysis, 2019.

Standardizing fishing gear is carried out by calculating the Fishing Power Index (FPI), which is the fishing gear's ability to catch fish to homogenize the effort standard of the five types of sizeable pelagic fishing gear in WPPNRI 715. After calculating the *fishing power index* (FPI) for each fishing gear, it is necessary to calculate the standard effort per fishing gear *(effort standard)*. The *standard effort* is obtained from the product of the effort with the FPI value of each fishing gear. The results of the standardization of sizeable pelagic fishing gear in WPPNRI 715 are seen in Table 3.

Value Per Unit Effort (CPUE) is recalculated with the catch (amount of production data) divided by the value of the new fishing effort or standard trip (effort standard). The results obtained can be seen in Table 4.

Fisheries Bioeconomic Model

To estimate the amount of considerable pelagic fish capture fisheries resources in WPPNRI 715 that can be utilized and estimate the cost of managing sizeable pelagic fish capture fisheries in WPPNRI 715, a comparison of the intrinsic growth rate *(r)*, catchability coefficient *(q)* and environmental carrying capacity *(K)* of each estimation model. The statistical test results of several bioeconomic models calculated by the researchers show that the Schaefer model with the Fox Algorithm approach is the best compared to other estimation models. This is in accordance with research by Zairion *et al.* (2020) which explains that based on biological and statistical parameter values, it appears that the most appropriate estimation model that can be used to describe and predict the condition of pelagic fish resource utilization is an estimation model using the Fox algorithm approach. The analysis results obtained by biotechnique. The results of the calculation of the biological parameters of the Schaefer model with the fox algorithm approach can be seen in Table 5.

Biological parameters show that the catchment coefficient *(q)* identifies that each increase per unit catch will have an effect of 0.0000008520 tons per trip with an intrinsic growth rate *(r)* of large pelagic fish in WPPNRI 715 will grow naturally without any disturbance from nature, human efforts or intrinsic growth rate of 1.4673520650 and carrying capacity of the waters *(K)* which indicates that the ecosystem supports production considerable pelagic fishery resources at WPPNRI 715 are 1,150,022.89 tons per year. The results of the bioeconomic Schaefer model by the fox algorithm approach can be seen in Table 6., Figure 1 and Figure 2.

Rents obtained in the *Maximum Economic Yield (MEY)* on the use of large pelagic fish fisheries in WPPNRI 715 for the 2011-2018 period of Rp. 3,065,588.97

Table 5. Biological Parameters of Large Pelagic Fish Catching Fisheries at WPPNRI 715

Coefficient	Description	Value
r	Intrinsic Growth Rate	1.4673520650
q	Catchability coefficient	0.0000008520
K	Water Carrying Capacity	1,150,022.89

Source: Data Analysis, 2019.

Table 6. Actual Conditions, MEY, MSY and OAY of Large Pelagic Fish in WPPNRI 715

	Equilibrium			
	Actual	MEY	MSY	OAY
Production (h) tons	320,444.42	368,522.25	421,872.11	386,691.47
Effort (E) (trip)	470,609	554,902	861,131	1,109,805
π (Million Rp.)	2,738,211	3,065,588.97	2,131,966.31	0

Source: Data Analysis, 2019.

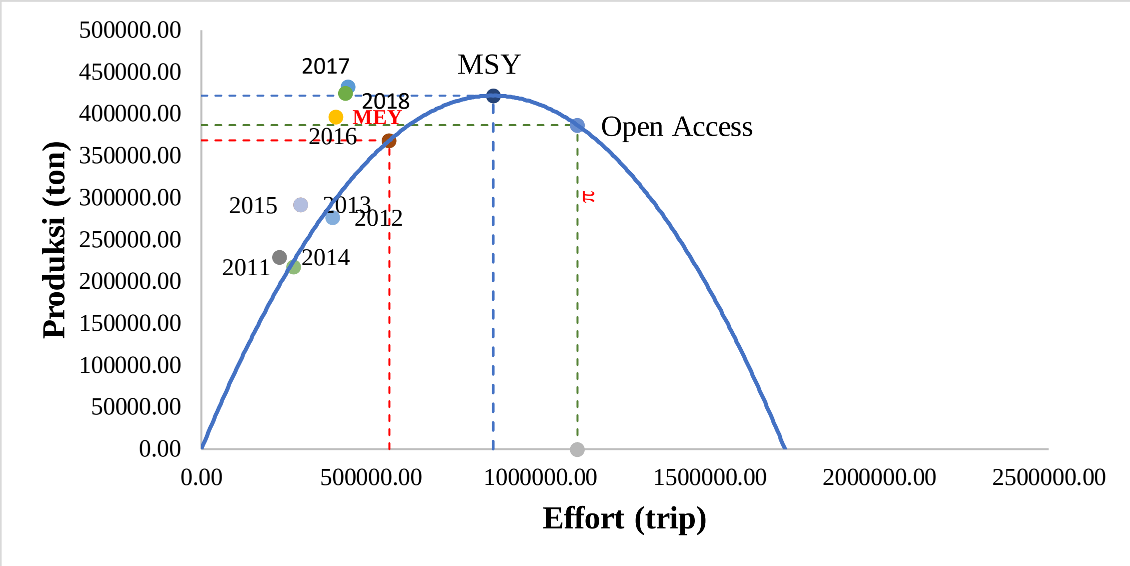

Figure 1. Actual production curve, fishing effort and sustainable production of Large Pelagic Fish in WPPNRI 715. (Source: Data Analysis, 2019).

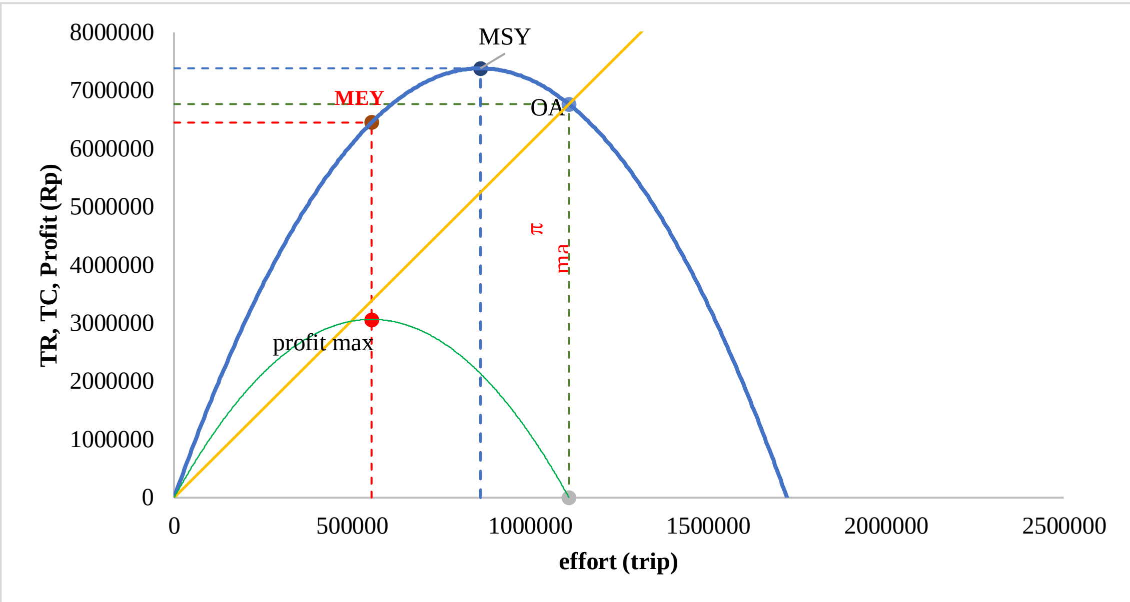

Figure 2. Actual rents, fishing effort and sustainable production of Large Pelagic Fish in WPPNRI 715. (Source: Data Analysis, 2019).

trillion, while the profit in the *Maximum Sustainable Yield (MSY)* regime is IDR 2,131,966.31 trillion. Then the cost of managing large pelagic fish in WPPNRI 715 based on optimal utilization of fishery resources at the maximum economic yield (MEY) can be seen in Table 7.

Cost calculation results The management of large pelagic fish fisheries in WPPNRI 715 with a bioeconomic fishery model shows that the budgeted management costs are more precise because they take into account the use of fish resources as a source of revenue and costs as expenses. The calculation result of the cost of managing

Table 7. Cost of Fisheries Management on Big Pelagic Fish in WPPNRI 715

Percentage of Relative Value of Fishery Management Costs	Large Pelagic Fish	
	Fishery Production Value	Maximum Economic Yield (MEY)
44.74 %	1,315,515.57	1,371,544.51

Source: Data Analysis, 2019.

large pelagic fishery in WPPNRI 715 using the fisheries bioeconomic model shows that the allocated management is more appropriate because it considers the utilization of fish resources as revenue and costs as expenditures. There are three levels of resource management in WPPNRI 715, namely at the MSY, MEY, and OAY levels (Arnason, 2023). Management at the MSY level depicts the maximum sustainable fish production that can be harvested without harming the existing fishery resources. Management at the MEY level depicts conditions that can provide optimal benefits without harming the sustainability of fishery resources. Management at the OAY position depicts the condition of fisheries where everyone is free to engage in fishing activities, in which case the profits obtained are only able to cover operational costs (break-even point/BEP) (Wong *et al.,* 2021; Rahayu *et al.,* 2022). Each fishing effort at the MEY level is more efficient compared to efforts at the MSY level, thus the economic benefits in the MEY condition are greater than in the MSY condition (Anna, 2018).

CONCLUSION AND POLICY IMPLICATION

The utilization level of large pelagic fish resources in WPPNRI 715 is in good biological condition, as evidenced by calculations indicating that actual production does not exceed sustainable production. Additionally, from an economic standpoint, the benefits derived from the utilization of large pelagic fish resources in WPPNRI 715 remain favorable. The Ministry of Marine Affairs and Fisheries' budgeted management costs for large pelagic fish in WPPNRI 715 account for 44.74% of the relative production value, totaling Rp1,315,515.57 trillion. However, when calculated based on the maximum rent, the fisheries management cost amounts to Rp1,371,544.51 trillion.

Based on the research results and with the aim of optimizing appropriate fisheries management for large pelagic fish in WPPNRI 715, it is necessary to implement policy measures. These policies should focus on the selectivity of the use of large pelagic fishing gear, especially for purse seine gear, to maintain the utilization level of large pelagic fish resources in WPPNRI 715, which is still in good condition (not exceeding the MSY value). Therefore, there is a need for increased evaluation, monitoring, and restriction of fishing vessels under 30 GT, given that the data on fishing effort using handline gear shows a significant and rapid increase. Policy recommendations regarding the calculation of fisheries management costs are suggested to be based on bioeconomic fisheries calculations. This ensures that the budgeted management costs align with the utilization of fisheries resources.

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