International Journal of Environment, Agriculture and Biotechnology
Vol-7, Issue-2; Mar-Apr, 2022

Journal Home Page Available: https://ijeab.com/
Journal DOI: 10.22161/ijeab

Peer Reviewed

Analysis of the Ecstasy Rate of Cakalang Fish (Katsuwonus pelamis) in the Flores Sea of South Sulawesi

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Received: 07 Jan 2022; Received in revised form: 20 Feb 2022; Accepted: 01 Mar 2022; Available online: 09 Mar 2022

***Abstract*— *The purpose of this study is to analyze the level of exploitation of cakalang fish in the Flores Sea of South Sulawesi. This study will be conducted in September - December 2021, keeping in mind the Covid-19 health protocol. The research method used is the survey method. The sampling method used is the method of taking the effort of the sample capture unit is done random sampling. The data analysis used is the estimation of biological parameters and maximum sustainable yield. The results showed that the condition of the maximum sustainable sustainable potential value in the Flores Sea has not been indicated to experience over fishing with an effort value of 2,215.11 units / year, a yield of 621,343.85 tons / year and Biomass of 306,574.77 tons / year*

***Keywords*— Level of Exploitation, Maximum Sustainable Yield.**

I. INTRODUCTION

The largest production of cakalang fish (Katsuwonus pelamis) in the Flores sea of South Sulawesi is one of them is in Bulukumba Regency and Selayar Islands Regency. Bulukumba regency is one of the most potential districts from the marine and fisheries aspect with an area of 1,154.67 km2 and a coastal length of about 128 km with a catch fishery production of 53,612.3 tons. Cakalang fish (Katsuwonus pelamis) in Bulukumba Regency is one of the marine fishery resources categorized as pelagic fish where the largest cakalang fish production recorded in 2018 amounted to 10,068.2 tons. As for the details of the production of cakalang fish (Katsuwonus pelamis) in Bulukumba Regency, namely in 2010 amounted to 2,528.3 tons, in 2011 amounted to 3,667.6 tons, In 2012 amounted to 5,400.2 tons, in 2013 amounted to 6,465.9 tons, in 2015 amounted to 4,114.5 tons, in 2016 amounted to 3,845.5 tons, in 2017 amounted to 3,995.7 tons, in 2018 amounted to 10,068.2 tons and in 2019 amounted to 3,247.8 tons. Similar to Bulukumba Regency, Selayar Islands Regency itself is estimated to have considerable cakalang fishery resource potential where cakalang fish production recorded in 2014 amounted to 2,010.8 tons.

Utilization of cakalang fish (Katsuwonus pelamis) with a dense intensity can cause several problems such as catches experiencing fluctuations every year, the time of catching is getting longer, the fishing area is getting farther and fishermen no longer choose the catch, for example cakalang fish that are still small in size. The basis in the management of fish resources is how to utilize resources so as to produce high economic benefits for business actors, but their sustainability is maintained.

Data on the utilization rate of a fish resource is very important, because it will determine whether the utilization of these resources is less than optimal, optimal, or excessive. Excessive utilization of fish resources will interfere with the level of sustainability. By knowing the level of utilization of fish resources is expected to be carried out planned and sustainable management. Existing problems need to be studied both in terms of exploitation of fishing activities using calculations of catch per unit effort (CPUE) utilization rate analysis, determination of Sustainable Potential Level, Optimum Effort, and

Utilization Rate of cakalang fish resources in the Flores Sea of South Sulawesi, where the information is needed in sustainable fisheries management in order to use cakalang fish (Katsuwonus pelamis) in the sea waters of Flores Sulawesi. South can run optimally (Budiasih and Dian, 2015)..

II. METHODOLOGICAL RESEARCH

A. Time and Location of Research

This study will be conducted in September - December 2021, keeping in mind the Covid-19 health protocol. The study was conducted in the waters of the Flores Sea. The areas that include flores sea waters include parts of Takalar Regency, Jeneponto Regency, Bantaeng Regency, Bulukumba Regency, Selayar Islands Regency, and part of Sinjai Regency which can be seen in appendix 1. In this study will use regional representation including Bulukumba Regency and Selayar Islands Regency as research locations. The selection of research locations (Regencies / Cities) was carried out purposively (intentionally) on the grounds that the selected regency could describe the waters of the Flores Sea as a whole where Bulukumba Regency was chosen because it was seen from the aspect of the highest cakalang fish production in the Flores Sea Waters of South Sulawesi as much as (2,528 - 10,068) tons in 2010 - 2018.

B. Research Methods

The research method used is the survey method. According to (Sugiyono, 2014: 7) Survey research is a study conducted on large and small populations, but the data studied is data from samples taken from that population, so that relative events, distribution, and relationships between sociological and psychological variables are found. In the survey method information is collected from respondents using questionnaires as research instruments. Questionnaire is a sheet that contains several questions with a standard structure. This research is both quantitative and analytical analytical. Quantitative is research that data from a sample of the study population is analyzed according to the statistical methods used. Quantative data is an assessment based on the amount of something. Analytical research is research that needs to be studied in several more detailed parts to understand the various relationships, properties and roles of these parts.

C. Sampling Methods

The method of sampling units is done random sampling is a sampling method by randomizing samples simply, in accordance with Prasetiyo (2005) which states that if the population is less than 100 then the sample is better taken all, but if the population is more than 100 then the sample can be taken between 10-15% of the population or depending on the ability of the researcher, the area and the size of the risk borne by researchers.

Respondents for the marketing aspect of cakalang fish using the Stratified random sampling method, is the process of sampling through the process of dividing populations into strata, selecting simple random samples from each stratum and combining them into a sample to estimate the parameters of the population. If the population is homogeneous, then the sample can be taken from any population, but if the population is heterogeneous, then the sample must represent from each heterogeneous part of that population so that the results of the study of the sample can be met with each member of the population. The process of dividing populations into stratum aims so that samples taken from each stratum can represent the characteristics of a large and heterogeneous population. Therefore, the stratum should be formed as well as possible with the characteristic manganesealysis of the population well (Demokrawati, 2014).

D. Data collection techniques

The data collection techniques used in this study are:

1. Interview, which is to conduct a systematic interview method that is an interview conducted by first preparing written guidelines about what to ask respondents.
2. Observation, which is to obtain the main data sourced from respondents in the form of fishermen's activities in the selected district.
3. Documentation, i.e. completes the analysis and strengthens the conclusions, all data and activities in the research are documented in the form of images.
4. Library Studies, which is to support the method of interview and observation that has been done. The collection of information needed in finding references related to the research conducted.
5. Questionnaire, which is a list of questions that must be answered or done by respondents

E. Data Source

The data sources used in this study are as follows:

1. Primary data, which is data obtained from interviews with respondents based on questionnaires that will be given later, for cakalang fishing unit business includes: investment and income. As for the marketing system includes: the identity of the respondent, the determination of selling and buying prices, the pattern of marketing channels, and marketing costs.
2. Secondary Data, which is data obtained from the District/City Marine and Fisheries Office that has been selected. Secondary data used in this study are: data on the number of cakalang fishing units and cakalang fish marketing agencies in Selayar and Bulukumba Islands Regencies.

F. Data Analysis

ISSN: 2456-1878 (Int. J. Environ. Agric. Biotech.)
https://dx.doi.org/10.22161/ijeab.72.1

The data analysis used in this study is as follows:

To answer the first problem formulation about the exploitation of fish. Data used in the Surplus Production method in the form of catch and capture effort, then processing data through the Schaefer Model and Fox Model approach which is a regression analysis model from CPUE to the amount of effort

1. Catch per Unit Effort (CPUE)

After the production and effort data (input or effort) were arranged in a time sequence according to the type of fishing gear, the next step is to find the catch per unit effort (CPUE). According to Ghulland (1991), CPUE calculation aims to determine the abundance and utilization rate of fishery resources in a certain water area. The CPUE value can be denoted as follows :

$$\mathbf{CPUE_t} = \frac{Catch_1}{Effort_1}$$

$$\mathbf{t = 1,2,...n}$$

Where :

$CPUE_t$ = catch per catch effort in year t

$Catch_1$ = the catch in year t

2. Standardization of fishing gear

Fishing gear standardization aimed to uniform effort different units, so it can be assumed that the effort to catch a type of fishing gear is the same as that of standard fishing gear. Standard fishing gear is based on the amount of catch obtained and the value of the fishing power index (FPI) with the input (effort/effort) of the standardized tool.

$$\mathbf{E_{std} = Y_{tot} / CPUE_{std}}$$

Where :

E_{std} : Effort/ standard fishing effort

$CPUE_{std}$: CPUE standard fishing gear

Y_{tot} : CPUE which is made the standard

3. Estimation of Biological parameters

Biological parameters include water carrying capacity constants (K), natural growth constants (r), technological parameters (q). Meanwhile, economic parameters include the cost per fishing effort (c / p), the price of Indian Scad fish per unit, the catch (p), and the discount rate. There are several approaches in estimating biological parameters, but in this study, the CYP estimation model (Clark, Yoshimoto and Pooley) is used with the approach and development of the Fox (1970) and Schunate (1977) model formulas, systematically the equation is written as follows: Clark *et al.*, (1992)

$$\mathbf{Ln\ (U_{t+1})} = \frac{2r}{(2+r)} Ln(q, K) - \frac{(2-r)}{(2+r)} Ln(U_t) - \frac{q}{(2+r)} (E_t + E_{t+1})$$

Where :

U_{t+1} = CPUE at time t+1

U_t = CPUE at time t

E_t = Effort at time t

E_{t+1} = Effort at time t+1

β_0 = regression result intercept coefficient

β_1 = coefficient X variable 1 regression results

β_2 = coefficient X variable 2 regression results

4. Dynamic Bioeconomic Analysis

The output of the bioeconomic model includes optimal stock (X *), optimal catch (Y *) and optimal fishing effort (E *) which are estimated using the equation, (Najamuddin, 2014):

$$\mathbf{X^* = K/4[c/qpK + 1 - \sigma/r) + \{(c/qpK + 1 - \sigma/r)^2 + 8c\ \sigma/qpKr\}^{1/2}]}$$

$$\mathbf{Y^* = rX^*\ (1 - X^*/K)}$$

$$\mathbf{E^* = Y^*/qX^*}$$

Where :

K : Environmental carrying capacity

c : Operating costs for catching the Cakalang Fish

p : the price of Cakalang Fish per kilogram

r : fish growth rate

q : catching power coefficient and fishing gear

σ : resource cut rate

The calculation of the Maximum Sustainable Yield (MSY) model uses the following equation:

$$\mathbf{E_{MSY}} = \frac{r}{2q}$$

$$\mathbf{Y_{MSY}} = \frac{\mathbf{Kr}}{\mathbf{4}}$$

$$\mathbf{X_{MSY}} = \frac{\mathbf{K}}{\mathbf{2}}$$

Where :

E_{MSY} : Efforts to catch MSY's condition

Y_{MSY} : The catch in MSY condition

X_{MSY} : Estimating optimal stock of MSY conditions

III. RESULTS AND DISCUSSION

A. Cakalang Fishing Efforts

Cakalang fishing efforts in the Flores Sea are carried out with the most dominant fishing gear, the Purse Seine. During the period 2011 - 2020 Cakalang fishing efforts in the waters of the Flores Sea can be seen in the following table.

Table 1. Development of Cakalang Fishing Efforts in the Flores Sea Based on Fishing Equipment For The Period 2011-2020

Tahun	Effort (Unit)				
	Rawai Tuna	Rawai Tetap	Pancing Tonda	Pancing Ulur	Pukat Cincin
2011	172	176	595	2.271	244
2012	175	153	635	2.331	168
2013	165	176	696	2.570	164
2014	162	160	729	2.570	171
2015	122	150	478	2.603	263
2016	140	145	478	2.894	452
2017	134	158	486	2.716	692
2018	117	196	666	3.037	207
2019	135	190	688	2.715	216
2020	137	197	700	2.383	213

Source: Secondary data after processing, 2022.

B. *Catch Per Unit Effort* (CPUE)

Catch per Unit Effort (CPUE) is a method used to determine the average amount of marine fishery production in years. Fishery production in an area experiencing an increase or decrease in production can be known from cpue result

Table 2. The magnitude or value of the catch per unit effort (CPUE) describes or reflects the level of productivity of the capture effort.

Tahun	Rawai Tuna	Rawai Tetap	Pancing Tonda	Pancing Ulur	Pukat Cincin
2011	5,156	0,455	0,738	0,208	12,778
2012	6,602	0,164	1,240	0,369	19,761
2013	0,480	0,146	0,935	0,619	31,43
2014	0,429	0,212	1,148	0,084	27,833
2015	15,606	0,109	1,432	0,303	3,084
2016	1,386	0,170	2,130	0,422	2,983
2017	2,012	0,118	0,496	0,539	11,16
2018	2,022	0,118	1,188	0,359	15,726
2019	1,813	0,151	1,064	0,079	12,395
2020	1,738	0,124	0,883	0,311	10,798

Source: Secondary data after processing, 2022.

C. Standardization of fishing gear

Cakalang fishing efforts in the Flores sea use the dominant fishing gear that is purse seine fishing gear. As for the reason for the selection of these fishing gear based on the real circumstances on the ground and input that this fishing gear is the dominant fishing gear for use to catch Cakalang fish in the area. Each unit of fishing gear has different abilities, both against the type and the number of species caught.

Standardization of fishing gear is needed to uniformize Cakalang fishing efforts consisting of various types of fishing gear. The determination of standardization of effort units in this study is the total effort per year of several fishing gear with time series data in 2011-2020 obtained from the Fisheries Office of Selayar Islands Regency and

Bulukumba Regency of South Sulawesi Province. The standard fishing gear used in this study is purse seine on the grounds that this fishing gear has a catch value per unit of effort greater than other fishing gear.

Table 3. Standardization of Cakalang Fishing Gear in the Flores Sea Waters of South Sulawesi in 2011-2020.

Tahun	Rawai Tuna	Rawai Tetap	Pancing Tonda	Pancing Ulur	Pukat Cincin
2011	0,404	0,036	0,058	0,016	1,000
2012	0,334	0,008	0,063	0,019	1,000
2013	0,015	0,005	0,030	0,003	1,000
2014	0,015	0,008	0,041	0,003	1,000
2015	0,524	0,035	0,464	0,098	1,000
2016	0,465	0,057	0,714	0,142	1,000
2017	0,180	0,011	0,044	0,048	1,000
2018	0,129	0,007	0,076	0,023	1,000
2019	0,146	0,012	0,086	0,006	1,000
2020	0,297	0,012	0,085	0,034	1,000

Source: Secondary data after processing, 2022.

Table 4. Standard Efforts of Cakalang Fish in the Waters of the Flores Sea

Tahun	Rawai Tuna	Rawai Tetap	Pancing Tonda	Pancing Ulur	Pukat Cincin
2011	69,405	6,265	34,37	36,929	244
2012	58,461	1,269	39,839	43,546	168
2013	2,519	0,815	20,695	50,622	164
2014	2,499	1,218	30,071	7,735	171
2015	617,392	5,279	221,953	255,928	263
2016	65,045	8,284	341,405	409,893	452
2017	24,162	1,666	21,604	131,226	692
2018	15,04	1,468	50,3	69,244	207
2019	19,748	2,31	59,043	17,24	216
2020	22,053	2,253	57,225	68,526	213

Source: Secondary data after processing, 2022

The following values from (C) that describe the level of productivity of the capture effort (effort) after strandarization of fishing gear can be seen in the following table.

Table 5. Productivity Level of Cakalang Fishing Efforts

Tahun	Produksi (Ton)	Total Effort Standard (Unit)	CPUE (Ton/Unit)
2011	4.024,80	390,97	10,29
2012	6.068,99	311,12	19,51
2013	7.720,80	195,35	39,52
2014	8.475,91	212,52	39,88
2015	4.787,70	810,11	5,91
2016	4.523,91	1.276,62	3,54

2017	4.304,11	870,66	4,94
2018	5.536,29	343,05	16,14
2019	3.896,11	314,34	12,39
2020	3.920,40	363,06	10,80

Source: Secondary data after processing, 2022

D. Estimated Biological Parameters of Cakalang Fish's Dynamic Bioeconomics Model in the Flores Sea

There are several estimation models that can be used to perform biological parameter estimation. but in this research. The estimation model used is an estimation model developed by Clark Yoshimoto and Pooley (1992) or better known as the CYP model. Biological parameters to be estimated include environmental carrying capacity (K). Catch (q) coefficient and fish growth rate (r).

The restoration of biological parameters with the CYP method requires logarithm input data from CPUE at time t + 1 and CPUE logarithm at time t as well as input data t Effort at the time of t and t + 1. To use OLS or regression, Ln CPUE t + 1 / CPUEt as Y, U_t + 1 as X1 and Et + 1 as X2 (Fauzi and Anna, 2010). In table 3 presented regression results from Cakalang Fish using the CYP estimation model.

Table 6. Cakalang Fish Regression Results with CYP Analysis Model

No	Estimasi	Parameter Regresi Ikan Cakalang		
		β_0	β_1	β_2
1	Coefficients	4,05346	0,00723	9,15E-04
2	Standard Error	0,11906	0,00065	1,24E-04
3	t Stat	34,0447	11,1521	7,36984
4	F	318,251		
5	R Square	0,99066		

Source: Secondary data after processing, 2022

The Ordinary Least Squares (OLS) model of Table 6 for Cakalang Fish is as follows Y = y = 34E-05x + 4.0534 R2 0.99.

From the data contained in table 6, the magnitude of the value of R2 of Cakalang Fish is 0.99, this indicates that independent variables in the equation have a strong influence and interrelationship to dependent variables.

The estimation results of the three parameters presented in table 18 are useful for determining sustainable production levels such as maximum sustainable yield (MSY). These values can be seen as follows:

Table 7. Estimated Results of Cakalang Fish Biological Parameters

No	Parameter Biologi	Hasil Estimasi	Satuan
1	Konsanta Laju Pertumbuhan alami ikan (r)	4,05346	ton per tahun
2	Koefisien penangkapan (q)	0,000915	ton per unit
3	Konstanta daya dukung Perairan (K)	613.149,54	ton per tahun

Source: Secondary data after processing, 2022

Biological parameters are one of the factors that greatly affect the survival of Cakalang fish. Because if one of the variables of biological parameters such as environmental carrying capacity is not in accordance with the needs then this will have an impact on the growth rate of Cakalang fish.

E. Sustainable Potential (Maximum Sustainable Yield) of Cakalang Fish

The key assumption of the sustainable potential model or sustainable harvest in maximum sustainable yield (MSY) is that the cakalang population grows and replaces itself, in the sense that the cakalang fish population is a renewable resource. The concept of sustainable catchment or Maximum Sustainability Yield (MSY), aims to maintain population size at the maximum point where the growth rate by harvesting would normally be added to the population, and allow that population to be productive forever (Hertini et al., 2013). To determine sustainable catchment or sustainable potential, a maximum sustainable yield management regime is used. The management regime model can be determined using analytical solving tools through excell programs. The results of the bioeconomics optimization analysis of each Cakalang Fish management regime in this study are succinctly presented in the following table.

Table 8. Results of Bioeconomics Optimization Analysis of Cakalang Fish Regression Utilization

Model	Effort (Unit)	Yield (Y) (Ton)	Biomass (X) (Ton)
MSY	2.215,11	621.343,85	306.574,77

Source: Secondary data after processing, 2022

IV. CONCLUSION

The level of ecstasy of cakalang fish in the waters of the Flores Sea is seen from the maximum sustainable yield has not been indicated to experience over fishing with an effort value of 35,506.20 Units / year, the yield of 30,161.10 tons / year and the actual production of the sustainable potential of kite fish in the bone bay water of 16,142.04 tons / Year, the fishing efforts carried out have not been optimal and the number of catches produced from 2011-2020 has not reached the maximum number (< MSY).

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