The utilization status of Yellowfin Tuna (*Thunnus albacares*) in Morotai Island Regency

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Abstract. Morotai Island Regency is located in the adjacent of three National Fisheries Management Area of Indonesian Republic (WPPNRI 715, WPPNRI 716, WPPNRI 717). Geographically Morotai Island's waters lie in two Indonesian hydro-oceanography phenomenon, namely Throughflow and Eddy Halmahera which affect the abundance of marine resources. This study aims to determine the utilization status of Yellowfin Tuna (*Thunnus albacares*) in Morotai Island regency including: catch per unit effort (CPUE), maximum sustainable yield (MSY), total allowed catch (TAC) and Utilization rate. Within a period of ten years (2009-2018) Yellowfin productivity was fluctuating with a CPUE of 4.1 kg/trip. Fox surplus production model calculation showed that MSY of yellowfin resource was amounted of 8,657,679 kg/year with a maximum effort value of 42,429 trips/year. The number of TAC value was amounted of 6,926,143 with a utilization level of 12.23%. Yellowfin utilization level was amounted of less than 33.3% which is relatively low. This shows that Yellowfin Tuna stock in Morotai Island regency has not been optimally utilized.

1. Introduction

Fish, as a marine resource, has as a high economic value for humans. The average global consumption of fish is 10 kg/person/year and increased to 20 kg/person/year in 2014 [1]. Fish consumption in Indonesia was amounted of 36.12 kg/year in 2015, with the average increase of 6.18%/year from 2011. Based on the fish consumption data, it is indicated that the demand for fish products increases from year to year, which allows the supply of fish products from capture fisheries to increase. The market demand for fish products is very high, which will lead to greater efforts that can threaten the sustainability of fisheries resources. Tuna has a very high market demand which will require a great effort in capture fisheries. Indonesia is a supplier of more than 16% of the world's tuna, skipjack and kawakawa, with average production of 1,033,211 tons. Indonesian tuna production is largely supported by capture fisheries in eastern Indonesia.

Morotai as Indonesian Border Area (Perpres No 34, 2015) has abundant marine and fisheries potential [2]. Geographically, Morotai Island is located near Pacific Ocean and also the entrance of the Indonesian Through flow or better known as ARLINDO. Due to hydro-oceanography, the location of Morotai Island is a route for water mass transportation from Pacific Ocean to the Indian Ocean [3]. These processes allow the water period to pass through a narrow area of the Indonesian archipelago resulting...
to the occurrence of water fertility indicators such as upwelling. In addition, the waters around the Halmahera Sea are the location of the Halmahera eddy current (Halmahera Eddy) which is formed due to a collision between two opposing currents, the Mindanao Current from the northern hemisphere and the Papua Northern Coast Current (New Guinea Coastal Current and New Guinea Coastal Under Current) from the southern hemisphere which forms the mass of Arlindo (Indonesian Through flow) at the eastern gate which is part of the global thermohaline current circulation. This condition causes a high source of nutrients from Pacific Ocean which also affects the high biodiversity of aquatic ecosystems.

Morotai Island Regency is located in Three National Fisheries Management Areas of the Republic of Indonesia (WPPNRI), namely WPPNRI 715, WPPNRI 716 and WPPNRI 717 [4]. Morotai is located on the Northern side of Halmahera Island and belongs to the North Maluku Province. Morotai is one of the border districts in North Maluku Province and directly adjacent with the Pacific Ocean.

Yellowfin Tuna potential in WPPNRI 713, WPPNRI 714 and WPPNRI 715 in the form of maximum sustainable yield (MSY) has yet to be determined. Total production in 2012 was amounted of 120,524 tons and the average production (2005-2012) was amounted of 46,126 tons. Whereas in WPPNRI 716 and WPPNRI 717, Yellowfin Tuna utilization levels are still uncertain. Based on the report of the 10th scientific meeting committee of the Western and Central Pacific Fisheries Commission (WCPFC), the potential of Yellowfin Tuna in the form of maximum sustainable yield (MSY) in all WCPFC management areas is estimated at 586,400 tons/year. Based on the calculation of F current / FMSY = 0.72, it can be concluded that the level of utilization of Yellowfin Tuna is not overfishing.

This study aims to analyze the utilization status of Yellowfin Tuna which includes catches per capture effort (Catch per Unit Effort), Maximum Sustainable Yield, Total Allowable Catch and Utilization level in Morotai Island Regency.

2. Theoretical review

Tuna is one type of superior commodity with high economic value. Yellowfin Tuna based on its taxonomy can be classified in the Phylum of Chordata, Sub-phylum of Vertebrate, Class of Teleostei, Sub-class of Actinopterygii, Order of Perciformes, Sub-order of Scombridei, Family of Scombridae, Genus of Thunnus, Sub-species of Thunnus albacares. Morphologically, Yellowfin Tuna is usually characterized by an elongated oblong body, dark metallic blue color on the back and turns yellow and silvery in the stomach [5]. Japanese tuna experts state that: 1) the IPFC (Indo Pacific Fisheries Commission) area seems to be considered as a meeting zone of yellowfin fish in the Indian Ocean and Pacific Ocean. These meeting places may be around the Flores Sea and the Banda Sea. However, the way and duration of the fish to associate is still uncertain; 2) Indian Ocean has two stocks of Yellowfin Tuna, namely western stock and eastern stock. Eastern stock is centered in the east including the Banda Sea and the Flores Sea. Both stock will associate on 100o E; and 3) Yellowfin Tuna in the IPFC area consists of eastern stocks from the Indian Ocean and Western Pacific Ocean stocks [6].

3. Methods

This research was conducted from January - June 2019 in Morotai Island, North Maluku Province. The method used was case study by using a survey. Survey research techniques was conducted with explorative descriptive aims with individuals/fishermen as the unit of analysis. In this study, data collection techniques were carried out by collecting primary data and secondary data. Primary data was obtained based on observations at the study site and interviews with fishermen. Yellowfin Tuna utilization level analysis was carried out using time series data within ten years (2009-2018). Sparre and Venema states that in calculating production surpluses, production data are used for at least five years [7].

3.1. Catch Per Unit Effort (CPUE)

CPUE is calculated using the equation [8]:

$$CPUE_i = \frac{Cacth_i}{Effort_i}$$

(1)
3.2. Maximum Sustainable Yield (MSY)
The maximum sustainable yield was determined using the Fox Model, optimum effort ($E_{opt}$) with equation below [9]:

$$E_{opt} = \frac{l}{b}$$  \hspace{1cm} (2)

$$MSY = \frac{l}{b} e^{a-1}$$  \hspace{1cm} (3)

3.3. Total Allowed Catch (TAC)
TAC calculated using the equation

$$TAC = MSY \times \frac{80}{100}$$  \hspace{1cm} (4)

3.4. Utilization Level (UL)
Utilization Level (UL) calculated using the equation

$$UL = \frac{Ci}{MSY} \times 100\%$$  \hspace{1cm} (5)

4. Result
Yellowfin Tuna in Morotai Island Regency is caught with only one type of fishing gear, namely handline. Therefore, there is no calculation of fishing power index (fishing gear standardization) in calculating fishing productivity. In addition, the condition of the Fish landing port/pier for Yellowfin Tuna is scattered in the villages which are the centres of the Yellowfin Tuna fishery (Sangowo Village, Daeo Village, Berebere Village and Wayabula Village).
Table 1. Yellowfin Tuna production, efforts/catch trips and CPUE [10].

| No. | Year | Total Production (Ton) | Effort (Fishing Trip) | CPUE |
|-----|------|------------------------|-----------------------|------|
| 1   | 2009 | 643,800                | 189,900               | 3.39 |
| 2   | 2010 | 1,019,700              | 225,000               | 4.53 |
| 3   | 2011 | 843,000                | 196,200               | 4.30 |
| 4   | 2012 | 1,475,000              | 196,740               | 7.50 |
| 5   | 2013 | 1,844,000              | 208,260               | 8.85 |
| 6   | 2014 | 1,219,000              | 186,840               | 6.52 |
| 7   | 2015 | 309,000                | 244,440               | 1.26 |
| 8   | 2016 | 325,000                | 244,440               | 1.33 |
| 9   | 2017 | 496,000                | 226,260               | 2.19 |
| 10  | 2018 | 294,670                | 268,020               | 1.10 |
|     | Total| 8,469,170              | 2,186,100             | 40.98|
|     | Average| 846,917             | 218,610              | 4.10 |

From Table 1 above, it can be seen the CPUE of Yellowfin Tuna effort in the Morotai Island Regency. The trend has fluctuated and tended to decline in recent years. CPUE value in 10 years is 40.98 kg/trip with a total effort of 2,186,100 trips. The average CPUE value is 4.10 kg/trip/year.

Yellowfin Tuna fishing is carried out with a one-day fishing system. The small capacity of the ship and ship hatch and inadequate fish handling facilities on the boat cause of fishing operations carried out in one day or generally 6-7 hours, this is done to maintain the quality of the fish. The fleet used in the fishing process in Indonesia is dominated by small scale and is still traditional in nature and the level of fishermen's science and technology are still low [11]. Production data for the last 10 years (2009-2018) shows that the total production of Yellowfin Tuna is amounted of 8,469,170 kg, with an average annual production of 846,917 kg/year. In the last four years, fishermen who have conducted fishing operations for yellowfin are oriented to the size and weight of this fish because the sale price of Yellowfin Tuna weighing ≥ 30 kg per head is more expensive than the weighing below. In addition, fishermen prefer the quality of fish meat to the quantity of catches. The assessment of tuna meat quality is based on its freshness level. If the quality is not met then the grade of the fish will be lowered to the local grade and the selling price will be even cheaper. Yellowfin Tuna Production has declined in the last four years (2015-2018) due to the fishing business-oriented paradigm of catch quality.

Table 2. Price and quality of Yellowfin Tuna [12].

| No. | Weight (kg) | Price (Rp) | Quality |
|-----|-------------|------------|---------|
| 1   | > 30        | 39,000     | Export  |
| 2   | 20 – 30     | 34,000     | Export  |
| 3   | 17 – 19     | 25,000     | Export  |
| 4   | 10 – 16     | 18,000     | Export  |
| 5   | 1 – 9       | 12,000     | Export  |
| 6   | > 20        | 20,000     | Domestic|
| 7   | 10 – 19     | 18,000     | Domestic|

In analyzing MSY, a suitable model for carrying out calculations in order to estimate the potential of fisheries resources in a sustainable manner must be determine. There are several criteria that are tested statistically, namely: 1) the suitability of the sign; 2) test the value of R2 (coefficient of determination); 3) the significance level of the regression coefficient; and 4) the standard error of the model used. The statistical test results of the surplus production model can be seen in table 3.
Table 3. Statistical criteria for a surplus production model.

| Validation               | Schaefer Model | Fox Model    | Walter-Hilborn Model | Schnute Model | CYP Model |
|--------------------------|----------------|--------------|----------------------|---------------|-----------|
| Conformity mark          | Fit            | Fit          | Not Fit              | Fit           | Not Fit   |
| R² value                 | 0.51           | 0.6994       | 0.1286               | 0.0349        | 0.8090    |
| Significance of          | Significant    | Significant  | Not significant      | Not significant| Significant|
| Regression Coefficients  |               |              |                      |               |           |
| Standard Error           | 2.0574         | 0.4504       | 0.5982               | 0.7817        | 0.4144    |

In Table 3, it can be seen that Fox Model fits the statistical test of the surplus production model to determine the value of MSY. The results of the validation conducted by the Fox Model has R² value of 0.6994, which is significant for the significance level of the regression coefficient and the standard error of 0.4504. In the CYP Model, R² showed the largest value compared to other model by 0.8090, and the smallest standard error by 0.4144. However, this model is not suitable for use because the results of the conformity sign test indicate that the value of b is negative, this is not appropriate because in the CYP model the value of b must be positive.

In figure 1, it can be seen that Yellowfin Tuna production tends to decrease in the last ten years. Calculation of the production surplus model with the Fox Model shows that the value of a (intercept) is 6.31837 and the value of b (slope) is -0.000023. Therefore, based on Fox Model, MSY level for Yellowfin Tuna in Morotai Island Regency are 8,657,678.85 kg/year with an optimal effort of 42,428.79 trips per year (figure 2).

Total allowable catch (TAC) is determined to estimate the level of Yellowfin Tuna exploitation below MSY. Therefore, TAC value is determined on 6,926,143.08 kg/year or 80% of the MSY value. Calculation of utilization level is obtained by comparing catches/year with MSY values from...
calculations based on the Fox Model. Utilization level of Yellowfin Tuna in Morotai Island Regency is considered low (<33.3%). The average utilization level from 2009 to 2018 was amounted of 12.23% with an average annual catch of 846,917 kg (Table 4).

| No. | Year | Production (ton) | Utilization Rate (%) |
|-----|------|------------------|----------------------|
| 1.  | 2009 | 643,800          | 9.30                 |
| 2.  | 2010 | 1,019,700        | 14.72                |
| 3.  | 2011 | 843,000          | 12.17                |
| 4.  | 2012 | 1,475,000        | 21.30                |
| 5.  | 2013 | 1,844,000        | 26.62                |
| 6.  | 2014 | 1,219,000        | 17.60                |
| 7.  | 2015 | 309,000          | 4.46                 |
| 8.  | 2016 | 325,000          | 4.69                 |
| 9.  | 2017 | 496,000          | 7.16                 |
| 10. | 2018 | 294,670          | 4.25                 |
|     | Average | 846,917        | 12.23                |

5. Conclusion
Morotai Island Regency has quite large potency of Yellowfin Tuna resource. However, it has not been optimally utilized. The utilization level of Yellowfin Tuna resource is still at 12.23%, which is relatively low. The productivity of Yellowfin Tuna fishing business is low due to the traditional fishing facilities used by fishermen and inadequate handling facility on board. Fishermen in Morotai Island Regency prioritize the good quality of the catch.

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