Tuna fisheries in fisheries management area Republic of Indonesia 572

by N Suyasa, P Rahardjo D R Putri And A Widagdo

IOP Conference Series: Earth and Environmental Science

PAPER • **OPEN ACCESS**

Tuna fisheries in fisheries management area Republic of Indonesia 572

To cite this article: N Suyasa *et al* 2020 *IOP Conf. Ser.: Earth Environ. Sci.* **441** 012087

Tuna fisheries in fisheries management area Republic of Indonesia 572

N Suyasa[1, 2], P Rahardjo[1], D R Putri[1] and A Widagdo[2]

[1]Study Program of Fisheries Resources Management, Jakarta Fisheries University, Pasar Minggu-South Jakarta, Indonesia
[2]Study Program of Capture Fisheries, Marine and Fisheries Polytechnic of Karawang, Karawang-West Java, Indonesia

[2]Corresponding author: soeyasa_stp@hotmail.com

Abstract. This research is expected to improve the sustainable tuna fisheries management of Fisheries Management Area Republic of Indonesia (FMARI) 572 by considering fish resources and fishermen welfare. The objectives of the research are examining the status of tuna fisheries in the FMARI 572, analyzing the *bioeconomic model* of tuna fisheries in the FMARI 572, and determining the strategy of a sustainable tuna fisheries management in the FMARI 572. This research was carried out for 3 months from February to May 2019 at the existing fishing ports located along the west coast of Sumatra (FMARI 572), such as Lampulo Fishing Port (Aceh), Sibolga Fishing Port (North Sumatra), Bungus Fishing Port (West Sumatra), and Nizam Zachman Fishing Port (Jakarta). Some factors analyzed were: The fishing capacity of fishing units with a variety of fishing gears, the potential of fish resources, the optimum level of efforts reaching the sustainable maximum catches, and the implementation of *fisheries bioeconomic models*. The results of this study showed the level of utilization tuna in FMARI 572 is still moderate, Tuna fisheries in FMARI 572 have not experienced *biological and economical overfishing*, and there were 3 sustainable tuna fisheries management strategies proposed.

1. Introduction

Tuna is a large pelagic fish genus of the Scombridae family and is a high-swimming fish species (high migratory species) [1,2]. In general, tuna (*Thunnus* spp.) Consists of 2 subgenus and 8 species [3], whose distribution is geographically located in tropical seas [1], such as the Atlantic, Indian and Pacific Oceans and the southern sea [4]. The kinds of tuna that are often traded include albacore, bigeye tuna, Atlantic bluefin tuna, Pacific bluefin tuna, southern bluefin tuna, and yellowfin tuna [5]. The development of world fisheries (especially tuna) has shown symptoms of overfishing in most fishing areas. This phenomenon is caused by high world fish demand due to population growth, increased income, and changes in tastes [6].

Indonesia as one of the tuna-producing countries in the world has resources that are spread almost in all territorial waters, and the Economic Exclusive Zone – EEZ [7]. Furthermore, Supriatna [8] informed that the area of tuna distribution in Indonesia is the Banda Sea, Maluku Sea, Flores Sea, Sulawesi Sea, northern Irian Jaya, northern Aceh waters, west coast of Sumatra, south Java, North Sulawesi, Tomini Bay, and the Arafura Sea. Indonesian tuna production in 2017, especially from the Indian Ocean, is as much as 165,725 tons [9]. The production consists of albacore tuna (6,994 tons); bigeye tuna (21,945 tons); yellowfin tuna (39,913 tons) and skipjack tuna (96,872 tons).

The Republic of Indonesia Fisheries Management Area (WPPNRI) 572 is one of the fisheries management areas under in the Indian Ocean Tuna Commission (IOTC) management area. In WPPNRI there are 3 (three) kinds of tuna, namely yellowfin tuna, albacore and bigeye tuna [10], where the utilization can be said to be not optimal. Departing from this condition, it is important to conduct research related to sustainable management efforts by taking into account the condition of fish resources and the welfare of fishermen, in order to obtain optimal economic benefits.

The aim of this study are (1) Examining the status of tuna fisheries in the FMARI 572, (2) Analyzing the bioeconomic model of tuna fisheries in the FMARI 572, (3) Determining the strategy of a sustainable tuna fisheries management in the FMARI 572. This research is expected to improve the sustainable tuna fisheries management of Fisheries Management Area Republic of Indonesia (FMARI) 572 by considering fish resources and fishermen welfare.

2. Materials and methods

This research was conducted for 3 (three) months from February to May 2017 in a fishing port located along the west coast of Sumatra (Fisheries Management Area 572). Data was collected at 4 places, namely: (1) Lampulo Fishing Port (Nanggroe Aceh Darussalam), (2) Sibolga Fishing Port (North Sumatra), (3) Bungus Fishing Port (West Sumatra), (4) Nizam Zachman Fishing Port (Jakarta). Data collection are done by conducting interviews directly with tuna fishermen, and periodic data (time series) of catches and fishing efforts during the last 10 (ten) years obtained from 4 fishing ports where the survey was conducted.

Data analysis performed was:

(1) Fishing efforts. The variety of fishing gear used to catch tuna (longline tuna, purse seine, hand line, and others) in the Fisheries Management Area 572 then it is necessary to standardize of efforts between fishing gear with standardization techniques by [11],

$$RFP_i = \frac{Ci/Ei}{Cs/Es}$$

Note:
RFP_i = the catching factor of the fishing unit which will become the standard in the i-year
C_i = the number of catches of the type of fishing unit to be standardized in the i year
C_s = the number of catches of the type of fishing unit used as a standard in the i-year
E_i = the number of fishing efforts the type of fishing unit to be standardized in the i year
E_s = the number of fishing efforts the type of fishing unit that is made standard in the i-year

After obtaining the RFPi value, then to calculate the fishing effort of the results of standardization, we use the formula:

$$\text{Effort Standard} = FPI_i \times \text{Effort}$$

(2) Production surplus model, to determine the optimum level of effort that is an effort that can produce a maximum sustainable catch without affecting stock productivity in a long time, which we call the maximum sustainable yield (MSY). MSY can be predicted using the formula [12]:

$$\text{Catches Per Unit of Effort}=\frac{Y}{f}=\frac{Y(i)}{f(i)}, i=1,2,\ldots\ldots n$$

Note:
Y(i) = catches in year i, i = 1,2, ... n
f(i) = fishing efforts in year i, i = 1,2 ...... n
Determination of the value of a (intercept) and b (slope) requires a linear regression f (i) to Y (i) / f (i). After the values of a and b are obtained, the optimum effort (fMSY) and maximum sustainable catch (MSY) can be calculated using the formula:

$$f_{MSY}=-\frac{a}{2b} \text{ dan } MSY=-\frac{a^2}{4b}$$

Furthermore, to determine the level of utilization of fish resources by presenting the amount of catch in a certain year with a maximum production value (MSY) [13]

$$\text{Utilization Rate} = \frac{Ci}{MSY}\times 100\%$$

Note:
Ci = the amount of catches in the year i
MSY = *Maximum Sustainable Yield*

(3) Biological analysis, to estimate the potential of fish resources, as well as to determine the optimum conditions of the level of fishing effort. The biological parameter estimation approach uses the Fox Algorithm estimation model. Biological parameter values (q, K, r) are obtained from calculations using the Fox Algorithm estimation model with the following formula [14]:

$$q = \text{geomean}\left|\ln\frac{\left(\frac{x}{y}\right)}{z}\right|$$

which

$$x = \left[\left(\frac{z}{CPUE_t}\right)+\left(\frac{1}{b}\right)\right]$$
$$y = \left[\left(\frac{z}{CPUE_{t+1}}\right)+\left(\frac{1}{b}\right)\right]$$
$$z = \left[\left(-\frac{a}{b}\right)-\left(\frac{CPUE_t+CPUE_{t+1}}{2}\right)\right]$$

Next to calculate other parameters such as K and r with the following equation [28]:

$$K = \frac{a}{q} \text{ dan } r = \frac{q^2K}{b}$$

Note:
K = ability capacity of the environment
r = growth rate coefficient
q = fishing gear capability coefficient

(4) Economic analysis, for estimating prices and costs for calculating bioeconomic models,
Economic parameters that influence the bioeconomic model in capture fisheries are the costs of catching in (c) and the price of catches (p). Fishing costs in the Gordon-Schaefer model bioeconomic study are based on the assumption that only fishing factors are taken into account. Average costs obtained from [10]:

$$c = \frac{\sum ci}{n}$$

Note:
c = average nominal fishing costs (Rp) per day per year
ci = nominal cost of fishing of the respondent i
n = number of respondents

The price of fish used is the average price in the i-year, the average price is obtained by the formula [10]:

$$p = \frac{\sum pi}{n}$$

Note:
p = average nominal price (Rp) per kilogram
pi = nominal price of the respondent i
n = number of respondents

(5) Fisheries Bioeconomic Model, to calculate the economic benefits or economic benefit obtained from fishery activities. In the Gordon-Schaefer model there are several assumptions such as the price per unit of output (p) (Rp / kg) assumed to be constant, the cost per unit of effort (c) is considered constant, only the fishing factor is taken into account, and others. With this assumption, the economic benefit obtained from fishery activities is obtained from the difference between the total sustainable revenue (TSR) and the costs incurred. TSR is obtained by multiplying the price per unit of fish sold (Rp / kg) and sustainable production as explained in the following equation [9]:

$$TSR = ph(E) = pqKE\left[1 - \frac{qE}{r}\right]$$

Gordon also assumes that total costs (TC) are linear with respect to inputs (effort) or [9]:

$$TC = cE$$

Thus, the economic benefit from fishing can be written as [9]:

π = TSR - TC atau π = ph - cE, maka $\pi = pqKE\left[1-\frac{qE}{r}\right] - cE$

Note:
TSR = sustainable total receipts (Rp)
TC = total cost (Rp)
π = profit (Rp)
p = average fish price (Rp)
h = catch (kg)
c = cost of catching unity of effort (Rp)
E = efforts (trip)

Based on the above formula, various conditions of resource use patterns can be estimated using formulas as listed in Table 1.

Table 1. Calculation Formulas in Optimal Resource Utilization [9, 26]

Variable	Condition		
	MSY	MEY	Open Access
Biomass (x)	$\frac{K}{2}$	$\frac{K}{2}\left(1+\frac{c}{pqK}\right)$	$\frac{c}{pq}$
Production (h)	$\frac{rK}{4}$	$\frac{rK}{4}\left(1+\frac{c}{pqK}\right)\left(1-\frac{c}{pqK}\right)$	$\left(\frac{rc}{pq}\right)\left(1-\frac{c}{pqK}\right)$
Efforts (E)	$\frac{r}{2q}$	$\frac{r}{2q}\left(1-\frac{c}{pqK}\right)$	$\frac{r}{q}\left(1-\frac{c}{pqK}\right)$
Economic Benefit (π)	$ph_{MSY}-cE_{MSY}$	$pqKE\left(1-\frac{qE}{r}\right)-cE_{MEY}$	$ph_{OA}-cE_{OA}$

3. Results and discussion

3.1 Fishing ground and fishing gear

Tuna catches landed at the observation site come from vessels using longline, purse seine and hand line with fishing ground in WPPNRI (WPP) 572. The distribution fishing ground can be seen through figure 1.

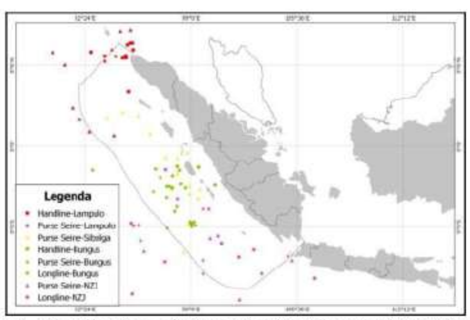

Figure 1. Distribution of Tuna Fishing Ground in WPP RI 572

Through figure 1, it can be explained that fishing ground with hand line, purse seine and longline are concentrated in waters around West Sumatra, this is because the sea of the western Indian Ocean especially West Sumatra has a high tuna potential. The high potential of tuna in West Sumatra is caused by water temperature ranged from 27.04ºC-30.17 ºC. In waters with water temperatures between 28ºC - 31ºC, yellowfin tuna are often found, so this area is a good fishing ground. While fishing ground for vessels with hand line are in the waters around Aceh and West Sumatra. While tuna longline are around 1° -8° S and 96° -103° East. Purse seine is the most dominant fishing gear in catching tuna in WPP 572, the fishing ground is also spread from Aceh to the tip of the island Sumatra.

Tuna caught on WPPNRI 572 consists of 3 kinds, namely yellowfin tuna *(Thunnus albacares),* bigeye tuna *(Thunnus obesus),* albacore *(Thunnus alalunga).* Three types of fishing gear that are dominantly used by fishermen to catch tuna are longline, purse seine and hand line. The distribution of tuna fishing gear on the west coast of Sumatra during the observation can be seen in Table 2

Table 2. Distribution of tuna fishing gear on the west coast of Sumatra.

Fishing Gear	Lampulo FP	Sibolga FP	Bungus FP	Nizam Zachman FP
Longline	-	-	+	+
Purse seine	+	+	+	+
Hand line	+	+	+	+

Note : (There is not) -; (There is) +

It can be explained in detail at Table 3:

Table 3. The number of tuna fishing gear in the observation site.

Year	Lampulo FP			Sibolga FP			Nizam Zachman FP		
	LL	PS	HL	LL	PS	HL	LL	PS	HL
2011	0	199	82	0	0	0	442	265	11
2012	0	298	22	0	106	168	366	345	15
2013	0	223	95	0	106	169	339	426	13
2014	0	241	98	0	108	161	280	523	23
2015	0	250	109	0	82	347	212	504	55
2016	0	259	95	0	97	316	182	498	55

Note: FP: Fishing Port, LL: Long Line, PS: Purse Seine, HL: Hand Line

Based on the composition of the catch, Albacore is the commodity with the lowest production volume (2%) and the yellowfin tuna (68%) is the commodity with the highest production volume. The proportion of tuna landings in WPPNRI 572 can be seen in figure 2. The low production of Albacore is related to the depth of the albacore swimming and the long line construction used. According to Bahtiar [19], the depth of albacore swimming in the Indian Ocean is in the range of 57.04 - 325.46 meters, while the results of interviews show that the depth of fishing lines from the long line used along the west coast of Sumatra ranges from 54.86 - 60 meters classified as surface type long line, where the depth of this line can be shorter because of the influence of curbenefit. According to Sumadhiharga [2] also explained that in Indonesia long line tuna which is commonly used is surface longline with depths until 50 meters. While the high production of yellowfin tuna indicates the abundance of these fish resources in WPPNRI 572. This statement is reinforced by the explanation that the most abundant distribution of yellowfin tuna is in the equatorial region between 3° LU-8° LS starting from the coast of Africa to the island of Sumatra [2].

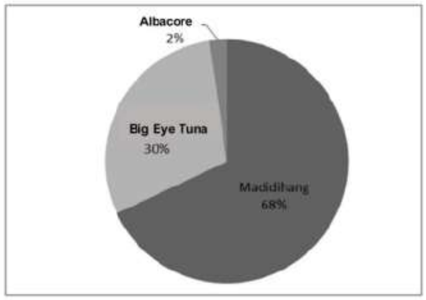

Figure 2. Proportion of tuna production at observation sites in 2016

3.2 Catch per Unit Effort (CPUE)

Catch per Unit Effort (CPUE) is a value that reflects the level of productivity of the fishing effort. Furthermore, by using the long line standard fishing gear, the CPUE value of tuna obtained in WPPNRI 572 can be seen in Figure 3.

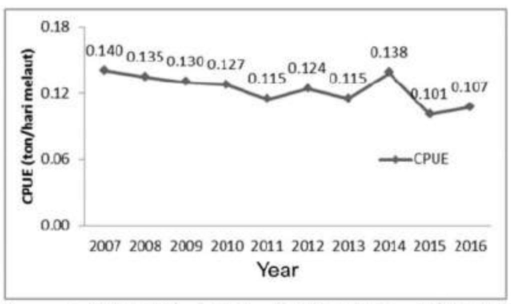

Figure 3. CPUE Tuna Value in WPP 572 in 2007-2016

The figure above shows the fluctuating CPUE value. In 2014 the value of CPUE increased sharply by 0.138 tons / fishing days and decreased in 2015 to 0.101 tons / fishing days. Several factors can affect CPUE values such as; (1) IUU fishing level, (2) fishing ground location, (3) fishing gear used and (4) natural conditions when operating.

Based on the analysis of the relationship between CPUE and effort (fishing effort), the value of a = 0.1469 and b = -0.0000002 are obtained so that the equation y = -0.0000002 + 0.1469. The graph of the relationship between CPUE and effort can be seen in Figure 4.

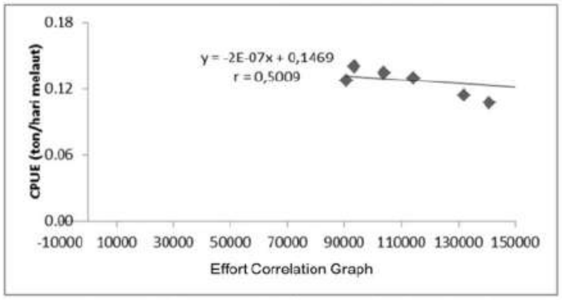

Figure 4. CPUE and effort correlation Graph

Based on the calculation results obtained correlation coefficient (r) of 0.50 which means that the relationship between fishing effort and CPUE have a sufficient correlation. It is said to be sufficient because the value of r obtained is in the range of 0.25 $<r\leq 0.5$. This statement is reinforced by Purnomo (2014) which stated that the value of the correlation coefficient with a range of 0.25 $<r\leq 0.5$ is included in the sufficient correlation criteria.

From the equation $y = -0.0000002x + 0.1469$ explains that each additional fishing efforts the CPUE will decrease by 0.0000002 tons / fishing days. The value of slope (b) is known to be -0.0000002 which can indicate the direction of linear regression. Negative correlation means that Catch per Unit Effort (CPUE) will decrease if the fishing efforts have increased. This is due to increased competition between fishing gears that operate where resources are limited and tend to decrease due to increased fishing effort.

3.3 Stock status

3.3.1 Maximum Sustainable Yield (MSY) and utilization rate

By using the production surplus model developed by Schaefer, we can calculate the estimated maximum sustainable potential of tuna in WPPNRI 572 as can be seen in Figure 5.

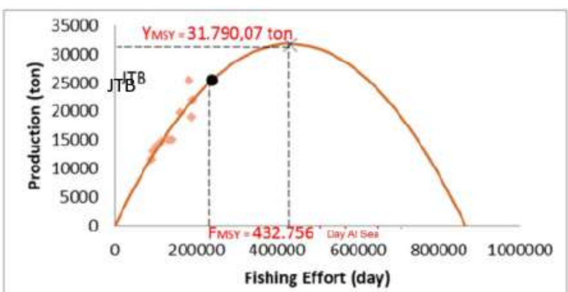

Figure 5. MSY Estimation of Tuna in WPP 572

MSY estimation of tuna with the Schaefer model produces a maximum yield of 31,790.07 tons at an effort rate of 432,756 days fishing. Based on the value of MSY obtained, the total catch allowed (TCA) is 25,432.06 tons. Based on the MSY value and actual tuna production in WPP 572 it can be seen that the utilization rate is 47.54%.

IOP Conf. Series: Earth and Environmental Science **441** (2020) 012087 doi:10.1088/1755-1315/441/1/012087

Thus, the results of the analysis of the utilization rate of actual production data with the MSY value of tuna fish resources in WPPNRI 572 reached 47.54%, or in other words tuna is still exploited below the MSY value. The level of utilization of tuna in WPPNRI 572 is included in the moderate category meaning that the resource stock is exploited with a low fishing effort. This was confirmed by [20,21,22] and [23] which state that the utilization rate is said to be at a moderate stage if the number of catches per year has not reached 80% of the specified MSY and an increase in the number of fishing efforts is highly recommended.

[24] in their study of large pelagic fish resources stated that the utilization rate of large tuna, especially yellowfin tuna, bigeye tuna and albacore in the western waters of Sumatra was 19.2%. When compared with the observations obtained the level of utilization of the three kinds of tuna are 47.54%, where these results have increased by 28.34% from previous studies. This shows that there has been an increase in tuna exploitation in the western waters of Sumatra.

3.4 Model bioeconomic analysis

3.4.1 Estimation of biological parameters

One technique developed to estimate biological parameters is to use the Fox Algorithm approach. The parameters estimated include the growth rate coefficient (r), the carrying capacity of the aquatic environment (K) and the fishing gear capability coefficient (q). The estimation results of the three parameters are useful for determining the level of sustainable production such as Maximum Sustainable Yield (MSY), Maximum Economic Yield (MEY) and the conditions of open access which are presented in Table 4.

Table 4. Estimated biological parameter results

Biological Parameter	Value
Growth Rate Coefficient (r)	1,35
Ability Capacity (K) (ton)	94.075,99
Fishing Gear Capability Coefficient (q)	0,00000156

Table 4 showed that the estimation of biological parameters using the Fox Algorithm approach shows that the growth rate coefficient (r) of natural tuna resources without any disturbance from natural phenomena or human activities is 1.35, and environmental ability capacity (K) indicates the ability of ecosystems to support production tuna resources amounted to 94,075.99 tons and the fishing gear capability coefficient (q) indicated that each increase in the fishing effort unit would produce a production of 0.00000156 tons.

3.4.2 Estimation of economic parameters

3.4.2.1 Estimated costs

The cost parameters examined in the bioeconomic analysis are only operational costs per effort. Cost data in this analysis were obtained from primary data through interviews with fishermen who caught tuna. Operational costs include the costs of fuel (diesel), oil, ice, fresh water, bait, and supplies. Because there are many fishing gear in this observation, standardization of costs is carried out. The results of the cost calculation for each fishing gear are presented in Table 5.

Table 5. Operating costs of each fishing gear

Type of fishing gear	Average cost (Rp per trip)	Cost Standardization	Operating costs (Rp per trip)
Longline	457.675.000	1,0000	457.675.000
Purse Seine	177.886.250	0,3887	69.139.713
Handline	252.324.391	0,5513	139.110.938
Mean			221.975.217
Average Operating Costs per Fishing days			1.470.035

The operational costs of each fishing gear are standardized as long line operational costs because this fishing gear is considered a standard fishing gear to catch tuna in WPPNRI 572.

3.4.2.2 Estimated price

In addition to the cost factor, in analyzing bioeconomics a price factor is also needed. The price factor influences the amount of revenue obtained in a fishing efforts. Price data are the average value of tuna prices prevailing in the observation area. The price of the tuna is presented in the form of a price per kilogram, which is obtained from secondary data and can be seen in Table 6.

Table 6. Average Tuna Prices.

Tuna	Average Price (Rp per kg)
Yelow fin tuna	36.209
Bigeye	63.298
Albacore	30.839
Mean	43.449

Bioeconomic analysis of tuna fish resources is carried out with a biological and economic approach. This approach is carried out to determine the optimal lev 8 of sustainable tuna farming. In this analysis, tuna management can be done in three conditions, namely Maximum Sustainable Yield (MSY), Maximum Economic Yield (MEY) and Open Access Equilibrium (OAE). The following results from the bioeconomic analysis with the Gordon-Schaefer model can be seen in Table 7.

Table 7. Bioeconomic Analysis of Tuna in WPP RI 572 under Actual Conditions; MEY; MSY and OAE.

Parameter	Management Alternatives			
	Actual	MEY	MSY	OAE
Production (ton)	16.988,42	30.104,15	31.790,07	22.539,93
Effort (day)	139.944,00	333.097,00	432.756,00	666.193,00
Economic Benefit (Rp juta)	532.833,96	818.317,80	745.066,78	0,00

The value of the production parameter shows the catch of the tuna resource utilization effort. Production in 2016 MSY conditions amounted to 31,790.07 tons. This catch is greater than the MEY and OAE conditions as well as the actual production which are respectively 30,104.15 tons; and 22,539.93 tons and 16,988.42. This condition shows that in the period 2007-2016 tuna fisheries in WPPNRI did not lead to biological overfishing, because the actual production value was still below sustainable production. Agree with [14] which stated that the biological overfishing occurs when the catch (production) under the actual conditions exceeds the production under MSY conditions.

While the value of fishing effort indicates the level of fishing effort used in fishing activities. The highest fishing effort was found in the OAE condition that is 666,193 fishing days. While the value of the arrest attempt on MSY's condition; MEY and Actual respectively are 432,756; 333,097 and 139,944 days to sea. The fishing efforts in the actual condition of 139,944 fishing days have not exceeded the fishing efforts in the other three conditions. This indicates that tuna fishing in WPPNRI 572 has not experienced economic overfishing because the actual level of effort has not exceeded the efforts in the MEY conditions that produce optimal profits.

This condition also produces the economic benefit value obtained in tuna fisheries that varies at each level of management. The largest economic benefit is found in the MEY condition, which is IDR 818,317.80 million. Economic benefit under conditions of MSY and OAE are respectively Rp. 745,066.78 million and Rp. 0. The value of Rp. 0 in OAE condition shows that fishermen only get wages for costs incurred in catching and do not get profits. The level of economic benefit in the actual condition was still lower than the MEY and MSY conditions. Therefore, fishermen can still increase the amount of production and fishing efforts to achieve greater economic benefit.

The condition of MEY, MSY and OAE in tuna fisheries management in WPPNRI 572 can be illustrated through the bioeconomic balance curve as shown in Figure 6.

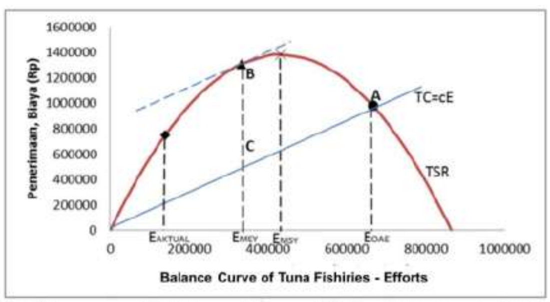

Figure 6. Bioeconomic Balance Curve of Tuna Fisheries in WPP RI 572

Figure 6 shows the economic benefit and fishing effort in each management condition. The economic benefit value is obtained from the intersection of the TSR (Total Sustainable Revenue) curve and the straight line TC (Total Cost). Under OAE conditions, economic benefit obtained by fishing effort of 666,193 fishing days is Rp. 0, where point A reflects that there is no distance between the TSR curve and the TC line, which means the value of economic benefit is zero. Point A is an open access equilibrium or fisheries balance in an open access condition. In this condition, a positive economic benefit will attract other fleets to participate in fisheries (entry process) so that the fishing effort will increase. Conversely, if the cost is greater than revenue (TC> TSR) there will be a reduction in the effort to catch (exit). This will continue until the economic benefits are drained. So that only at the point E = EOA the exit and entry process will stop.

The BC line on the curve shows the distance between the TSR curve and the TC line which produces the maximum economic benefit compared to the distance when the TSR curve reaches its maximum point with the TC line. This can be proven from the results of calculations under the MEY condition, economic benefit obtained with an effort to catch 333,097 fishing days amounted to Rp 818,317.80 million, whose value is higher than the economic benefit under MSY conditions with a fishing effort of 432,756 fishing days which is Rp 745,066, 78 million.

IOP Conf. Series: Earth and Environmental Science **441** (2020) 012087 doi:10.1088/1755-1315/441/1/012087

Meanwhile, the equilibrium curve also shows the actual economic benefit that was obtained at Rp. 532,833.96 million with a fishing effort of 139,944 fishing days. Seeing the actual conditions, fishing efforts can still be increased until an economic benefit is obtained from the maximum economic catch of tuna (benefit in the MEY condition).

3.5 Tuna fisheries management efforts

Based on the results of a bioeconomic analysis of tuna fisheries conducted, it is known that tuna fisheries in WPPNRI 572 have not experienced biological and economic overfishing. This biological overfishing and economic overfishing condition if left unchecked without control, will eventually deplete the stock and threaten the preservation of tuna fishery resources which can result in a decline in the welfare of fishermen.

Seeing the results of the analysis, the proposed management strategy are as follows:

1. Addition of fishing effort in the form of a longline fleet which is the most selective fishing gear to catch tuna. However, the addition of the fleet are also needed control so that the balance in the population is maintained.
2. Upgrading of longline fishing gear in the form of changing of the fishing rod, from the shape of J-hook to circle-hook in order to reduce or avoid the bycatch in the form of sea turtles.
3. Tightening supervision on the number of use of FADs and enforcing strong laws such as giving sanctions to violators. Installation of FADs that exceed the provisions if left unchecked can disrupt the preservation of tuna resources, because tuna caught with purse seine is small tuna.

4. Conclusion

Tuna caught on WPPNRI 572 are yellowfin tuna *(Thunnus albacares),* big-eye tuna *(Thunnus obesus)* and albacore *(Thunnus alalunga),* with a composition dominated by yellowfin tuna (68%) and then followed sequentially by bigeye tuna (30%) and albacore (2%). The production of tuna initially increased from year to year and then declined significantly since 2014. The three types of tuna are caught by using long line, purse seine and hand line. The phenomenon of shifting types of fishing gear has become interesting in recent years, because for long lines the number tends to decrease from year to year, while the opposite occurs in purse seine fishing gear. The results of the calculations using the Schaefer approach and a standardized fishing gear, obtained an MSY estimate for tuna in WPPNRI 572 amounting to 31,790.07 tons / year with an effort rate of 432,756 fishing days. If the results of the calculation of this MSY estimate are compared with the actual production of tuna in the last year, then the level of utilization of tuna resources has only reached 47.54% (moderate category). Using the Bio-economic approach, the utilization of tuna fish resources in WPPNRI 572 can still be increased to a Maximum Economic Yield (MEY) production rate of 30,104.15 tons / year, with an effort rate of 333,097.00 fishing dayss and an economic benefit of Rp 818,317,800,000 , -. Utilization of tuna resources can also be increased to the Maximum Sustainable Yield (MSY), whose total production reaches 31,790.07 tons / year with an effort of 432,756.00 fishing days and economic benefit of Rp. 745,066,780,000.

References

[1] Djuhanda T 1981 *World Fish* Armico, Bandung, 158, 159.
[2] Sumadhiharga O K 2001 *Tuna Fisheries in Indonesia* Pusat Penelitian Oseanografi-LIPI.
[3] Graham J B and K A Dickson 2004 *J. Exp. Biol.* 207(23): 4015-4024.
[4] Arrizabalaga H, F Dufour, L Kell, G Merino, L Ibaibarriaga, G Chust, & S Bonhomeau 2015 *Global Habitat Preferences of Commercially Valuable Tuna* Deep Sea Research Part II: Topical Studies in Oceanography, **113**: 102-112.

[5] Majkowski J, H Arrizabalaga, F Carocci, and H Murua 2011 *Review of The State of World Marine Fishery Resources: Tuna and Tuna-like Species* FAO Fisheries and Aquaculture Technical Paper **569**: 227-243.
[6] Zulbainarni, N & A. I. Purnama. (2013). *Pendekatan Bioekonomi Multispesies Untuk Keberlanjutan Pengelolaan Sumberdaya Perikanan Indonesia: Evaluasi Perikanan Tuna di PPN Palabuhanratu, Sukabumi, Jawa Barat.* Simposium Nasional Pengelolaan Perikanan Tuna Berkelanjutan, 774-789.
[7] Pramoda R and R Triyanti 2014 *J. Borneo Adm.* **10** (3).
[8] Supriatna A 2015 *Model of developing tuna fisheries supply chain in Indonesia.* Institut Pertanian Bogor.
[9] Ruchimat T Z Fahmi, B Setyadji and T Yunanda 2018 *Indonesia National Report to the Scientific Committee of the Indian Ocean Tuna Commission* IOTC-2018-SC21-NR09
[10] Wijopriono and A S Genisa 1999 *Some Biological Aspects, Potentials, and Distribution of Tuna and Skipjack in the Waters of West Sumatra* Prosiding Seminar Kelautan Regional Sumatera II, 309-313.
[11] Maunder M N and A E Punt 2004 *Fish. Res.* **70** (2): 141-159.
[12] Sparre P and S C Venema 1999 *Intoduction of Tropical Fish Stock Assessment. Collaboration between the FAO and the Center for Agricultural Research and Development.* Jakarta.
[13] Sutisna D H 2007 *Model of Capture Fisheries Development in the South of West Java Waters* Institut Pertanian Bogor.
[14] Zulbainarni N 2012 *Theory and Practice of Bioeconomic Modeling in Capture Fisheries Management* IPB Press. Bogor.
[15] Sobari M P, Diniah and Isnaini 2009 *Jurnal Mangrove dan Pesisir* **9** (2)
[16] Firman 2008 *Bioeconomic Model of Crab Resource Management in Pangkajene Regency and Sulawesi, South Sulawesi* Institut Pertanian Bogor.
[17] Fauzi A and S Anna 2005 *Modeling of Fisheries and Marine Resources* (Jakarta: Gramedia Pustaka Utama)
[18] Purnama A I 2014 *Bioeconomic Study of Rawai Tuna Fisheries at PPN Palabuhanratu, Sukabumi, West Java* Institut Pertanian Bogor.
[19] Bahtiar A, A Barata, and B. Nugraha 2014 *Swimming layer and feed time of Albacore (Thunnus alalunga) in Indian Ocean (Southern of Java)* Bawal **6** 2: 89-94.
[20] PerMen-KP Number 1 Year 2009 concerning *the territory of the Republic of Indonesia Fisheries Management.*
[21] PerMen-KP Number 26 Year 2014 concerning *FADs.*
[22] PerMen-KP Number 29 Year 2012 concerning *Guidelines for the Preparation of Fisheries Management Plans in the Field of Fishing.*
[23] FAO 1995 *Code of Conduct for Responsible Fisheries* Food and Agriculture Organization of the United
[24] Uktolseja J C B, R Purwasasmita, K Susanto, and A B Sulistiadji 1997 *Big Pelagic Fish Resources.* Komisi Nasional Pengkajian Stok Sumberdaya Ikan Laut. LIPI. Jakarta.

Tuna fisheries in fisheries management area Republic of Indonesia 572

ORIGINALITY REPORT

6%	5%	3%	1%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	researchnow.flinders.edu.au Internet Source	1%
2	ijariie.com Internet Source	1%
3	repository.bilkent.edu.tr Internet Source	<1%
4	ejournal-balitbang.kkp.go.id Internet Source	<1%
5	Gatut Bintoro, Daduk Setyohadi, Djoko Tri L, Affif Rofiiqoh N, Almira Syawli, Muammar Kadhafi. " Sustainable management of fisheries resources in Java Sea: Utilization status of longtail tuna ( ) in Indramayu waters West Java case study ", E3S Web of Conferences, 2022 Publication	<1%
6	Kitagawa, Takashi. "Behavioral Ecology and Thermal Physiology of Immature Pacific	<1%

Bluefin Tuna", Physiology and Ecology of Fish Migration, 2013.
Publication

7	www.wcpfc.int Internet Source	<1 %
8	Submitted to University Of Tasmania Student Paper	<1 %
9	environment.gov.au Internet Source	<1 %
10	Jabbar Khaledi, Patrick N.J. Lane, Craig R. Nitschke, Petter Nyman. "Wildfire contribution to streamflow variability across Australian temperate zone", Journal of Hydrology, 2022 Publication	<1 %
11	epdf.tips Internet Source	<1 %
12	scholars.uow.edu.au Internet Source	<1 %
13	www.semanticscholar.org Internet Source	<1 %
14	Natacha Nikolic, Gilles Morandeau, Ludovic Hoarau, Wendy West et al. "Review of albacore tuna, Thunnus alalunga, biology, fisheries and management", Reviews in Fish Biology and Fisheries, 2016 Publication	<1 %

15	Nguyen Dang Hoang Thu, Rachel Sundar Raj, Cao Le Quyen, Le Thi Minh Hang, Nang Thu Tran Thi, Philippe Lebailly. "Gender Analysis of the Tuna Value Chain's Purchasing Stage in the South Central Provinces of Vietnam-Case Study of Binh Dinh Province", Asian Social Science, 2020 Publication	<1%
16	P Reglero, DP Tittensor, D Álvarez-Berastegui, A Aparicio-González, B Worm. "Worldwide distributions of tuna larvae: revisiting hypotheses on environmental requirements for spawning habitats", Marine Ecology Progress Series, 2014 Publication	<1%
17	docs.niwa.co.nz Internet Source	<1%
18	iccat.int Internet Source	<1%
19	sportdocbox.com Internet Source	<1%
20	www.fao.org Internet Source	<1%

Exclude quotes On

Exclude matches Off