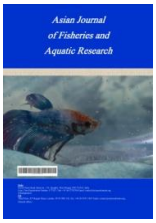

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Fisheries Production of Tuna Caught by Tuna Longline that Landed in the Fishing Port of Nusantara Palabuhanratu District Sukabumi, Indonesia

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Authors' contributions

This work was carried out in collaboration among all authors. Author NA designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors DS and EL managed the analyses of the study. Author HH managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

This study conducted statistical data retrieval at the fishery port of Nusantara (PPN) Palabuhanratu Sukabumi District, Indonesia to analyze the production of tuna fish. Analyzing the index of production values and analyzing the sustainable catches on the tuna, especially with the Tunas longline catch in PPN Palabuhanratu Sukabumi regency. The study was conducted from November 2019 to March 2020. Methods used are survey methods and quantitative analysis. The results of the study showed the average production of three types of tuna (large eye Tuna, yellowfin Tuna and Tuna Albakor) in PPN Palabuhanratu period 2010-2019 is 5,693 tons/year with the average value of Rp. 99.634.022.955 yearly production, The production of tuna (large eye Tuna, yellowfin Tuna and Albakor tuna) in PPN Palabuhanratu affects 67% of the production of capture fisheries

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that landed in PPN Palabuhanratu during the period of 2010-2019, then the relative index of tuna production value in PPN Palabuhanratu showed an average value of 1.41, means the production value of the three types of tuna (yellowfin Tuna and Tuna Albakor) in PPN Palabuhanratu is higher than the value of the overall production of fish in PPN Palabuhanratu, with a production of 5,693 tons/year, the production already touched the state of overfishing, because it passed the MSY limit of 4,737.05 tons/year.

Keywords: Tuna fish; PPN palabuhanratu; production.

1. INTRODUCTION

Tuna fisheries is the second export commodity after shrimp which has donated the foreign exchange of US $250.57 million in 2006 with the growth in the export volume of the last 25 years by 6.03%. Positive export volume growth indicates increased demand and exploitation of tuna in tuna producing areas such as Palabuhanratu, because tuna is an export commodity with high demand and economical value [1].

There are 19 types of dominant fish that are landed in the PPN (Peta Pelabuhan Ratu) Palabuhanratu, District Sukabumi. Tuna fisheries became the main mainstay with the biggest catch of other fish caught during the last 5 years with the production of large eye tuna amounting to 10,147,307 kg, followed by a tuna yellowfin with 7,300,692 kg and tuna albakor of 2,957,147 kg during the last 5 years period (PPN statistical Data Palabuhanratu 2017). The high production of tuna in PPN Palabuhanratu because of the location of PPN Bay that directly faced with the Indian Ocean, in which the Indian Ocean is a tuna ruaya area to Eastern Indonesia, which in general fishermen in PPN catch tuna using the Rawai tuna/Tuna Longline capture equipment with ship size 20 GT-100 GT [2].

Indian Ocean Tuna Commission (2016) said that the arrest of Tuna in 2015-2016 in the Indian Ocean decreased by 40%. Data on the stock of tuna resources, especially in the western part of the Indian Ocean has also suffered a considerable decrease by 30% over the last few years. This decline is generally caused by illegal unreported, and unregulated (IUU) fishing (FAO 2014). For example at the condition of tuna big eye fish/Big Eye Tuna in one of the fisheries management Area 573 already at the stage overfishing in 2014 based on the estimated potential fish resources Minister of KP No. 45/MEN/2011 [3], if the arrest is not restricted then in the long term will be a decline in the capture production that will lead to a decrease in 2016.

Production of the most special tuna fishery by longline tuna catchment which was landed at PPN, Sukabumi District, is very important to know and researched so that the manager of the port can learn about the catch of tuna and can compare the catch of tuna that landed in VAT (VILLA PELABUHAN RATU) Palabuhanratu Sukabumi District against all marine fisheries production in VAT District Sukabumi, which is because tuna production became a mainstay in the VAT, District Sukabumi and can know the factors that cause the fluctuations.

2. METHODOLOGY

Research conducted in PPN Palabuhanratu District of Sukabumi period from November 2019 to March 2020, with method of interview and quantitative analysis, statistical data of PPN, District of Sukabumi period year 2010 to 2019. Research is conducted with the aim of analyzing and determining the production value of tuna production, the index of production value and the sustainable capture/maximum sustainable yield of the tuna that landed in PPN Palabuhanatu.

3. RESULTS AND DISCUSSION

3.1 Tuna Production and Production Value

Calculation of catch and production value of tuna which is said to be based on the PPN is done by grouping the statistical data available in PPN based on the time sequence with variable tuna catch (in Tons) and production value (in Rp) and a descriptive analysis was carried out on the development of production and production value of tuna in PPN Palabuhanratu by comparing it with the production and production value of the previous years in order to obtain the prospects of the tuna fishery market landed at PPN [4].

3.2 Analysis of Production Value Index

The production value index is calculated for the last 10 years using the formula [5]:

$$\mathrm{I} = \frac{NP\ x\ QT}{NT\ x\ QP}$$

Information;

I: Relative index of production value
NP: tuna production value in PPN Palabuhanratu (Rp)
Nt: Production Value of all fish in PPN, Sukabumi (Rp)
Qp: Quantity or volume of tuna production in PPN (ton)
Qt: Quantity or production volume of all fish in PPN (ton)

3.3 Sustainable Catch/Maximum Sustainable Yield (MSY)

Estimation of sustainable catch / maximum sustainable yield begins with the calculation of CPUE which aims to determine the abundance and level of fish use based on the division between the total catch (catch) with the effort to catch (effort). The catch is the output of the fishing activity, while the effort needed in principle is an input from the fishing activity. Based on the production value and the number of trips made, the CPUE value for each fishing gear can be calculated, with the catch formula (production) of each fishing gear divided by the effort (trip) [6].

The formula used to determine the CPUE value is as follows [7]:

$$CPUE = \frac{Catch}{Effort}$$

Information,

CPUE: catches per capture attempt in years (tons / trip)
Catch: catches in years (tons)
Effort: arrest attempt in the year (trip)

MSY (maximum sustainable yield) is the biggest catch that can be produced by a stock of fisheries resources. The MSY concept is based on a fish population model that is considered a single unit. In principle, fish resources have the ability to produce that exceeds the production capacity (surplus), so that if the surplus is harvested, the fish will be able to survive continuously. If the level of surplus production is harvested, it will not disturb the sustainability of fish resource stocks.

Table 1. Schaefer Linear Model

Analysis	Schaefer model
MSY	$MSY = -0{,}25 * \frac{a^2}{b}$
EMSY	$\mathrm{E}MSY = -0.5 * \frac{a}{b}$

Sources; [8]

Table 2. Production (Kg) Fish with a variety of fishing gear

Tuna Production Year	Catching Tool				
	Gill Net	**Trolling Rod**	**Payang**	***Purse Seine***	***Tuna Longline***
2010	35,858	829,231	92,496	19,064	4,142,379
2011	120,502	970,592	41,432	-	3,213,076
2012	12,871	815,197	11,971	18,142	4,798,316
2013	11,900	813,425	14,702	-	4,931,274
2014	3,119	543,858	26,531	103	6,631,986
2015	110	549,649	22,098	20,000	4,790,955
2016	65	275,035	27,323	-	1,987,961
2017	-	560,082	6,805	-	1,083,305
2018	-	575,598	5,181	4,364	785,713
2019	-	375,423	7,290	6,340	1,730,359
Total	184,425	6,308,090	255,829	68,013	**34,095,324**

Source: Processed Data on PPN Palabuhanratu Statistics for 2020

3.4 Fish Production Based on Fishing Equipment

The production of fish entering the PPN Palabuhanratu via the sea route comes from bouke ami fishing gear, huhate, gill net, trolling, payang, purse seine, and longline tuna, transport vessels and other fishing gear. In this discussion, the fishing gear that is analyzed in tuna production is only the longline tuna / tuna longline fishing gear and the others become a comparison to see how the production and efficiency of catches with longline tuna.

If it is seen that tuna production with longline tuna fishing gear reaches 34.095,324 kg, from these data that the longline tuna fishing gear has an 83% role in the capture fisheries production in PPN. The production of tuna with longline tuna fishing gear can be the highest in PPN because of the use of 800-1000 hooks in one setting which catches a minimum of 40% of the number of hooks used in one keli setting and in one day can do up to 2 times the setting process. In addition, this fishing gear is selective towards its catch and its operation is passive, so it does not damage aquatic resources.

Production of tuna with longline tuna fishing gear is greater than other fishing gear due to tuna longline is an effective fishing gear and specifically intended to catch tuna, because its construction is able to reach the depth of the swimming (Swimming layer), it is very suitable to be operated in the waters of EEZ (Exclusive Economic Zone), and the use of fishing rods up to 1000 in one setting, compared with other fishing equipment in the form of a net that cannot reach the swimming layer of tuna.

3.5 Tuna Production with Longline Tuna Fishing Equipment

The production of tuna with longline tuna fishing gear in PPN Palabuhanratu is the production of capture fisheries in greater numbers than other fishing gears because the main target is tuna and has a high selectivity. Longline tuna selectivity lies in the hook.

Based on the graph of tuna production (Fig. 1) analysis of tuna production by longline tuna catches in the period of 2010-2019 as a whole is 34,095 tons, then in 2010-2014 the catch production in PPN is at 4,000-tons except in 2011 which decreased by 22.43% from the previous year. The highest catch occurred in 2014 amounting to 6,632 tons, 34.49% up from the year before, then there was a significant decrease in catch that is at 58.51% in year 2016 with a production figure of 1,988 tons and continues to decline gradually until it reaches its lowest point in 2018, touching 786 tons or 2% of the total catch during 2010-2019 period.

The decline in catches that occur in PPN Palabuhanratu is caused by a decrease in the number of fishing gear, the number of boat trips and also illegal, unreported, and unregulated (IUU) fishing activities. Besides that, the decline in tuna stocks at sea is because in 2014 tuna production has passed the MSY point of 4,737.40 tons (Fig. 4).

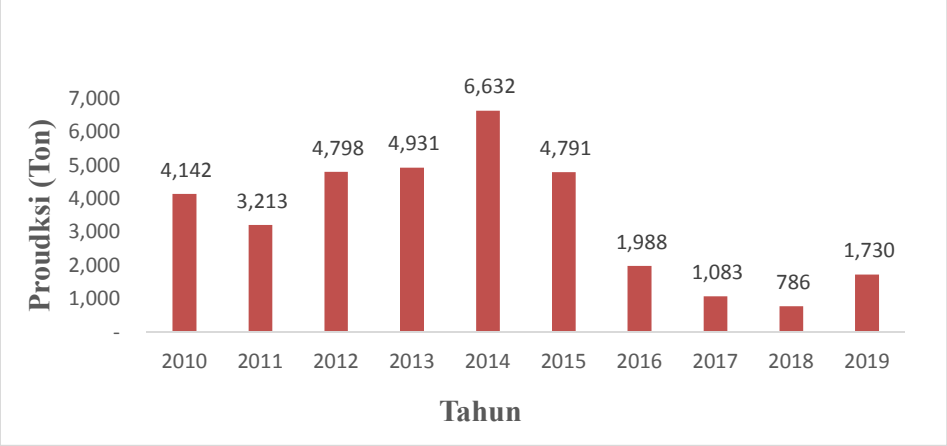

Fig. 1. Tuna Fish Production
Source: Processed Data on PPN Palabuhanratu Statistics for 2020

3.6 Tuna Production and Production Value

Fish production that is landed in PPN Palabuhanratu comes from the catch of domicile fishing vessels (Palabuhanratu) and incoming fishing vessels including those from Cilacap, Cirebon and Jakarta. Catch and production value of fish landed in PPN Palabuhanratu in 2010-2019 can be clearly seen in the table of tuna production in PPN Palabuhanratu.

Tuna fisheries production in PPN Palabuhanratu in 2010-2014 experienced a tendency to increase in 2011-2014 slowly but in 2015-2019 experienced a drastic decline, until 2018 when it reached the lowest for the last 10 years, 609 tons. The highest production occurred in 2014 which amounted to 6.580 tons, which is an increase in production by 42.53% from the previous years, then after that in 2015 it decreased by-32.03% (4,472 tons) from 2014 then there was still a drastic decline in the

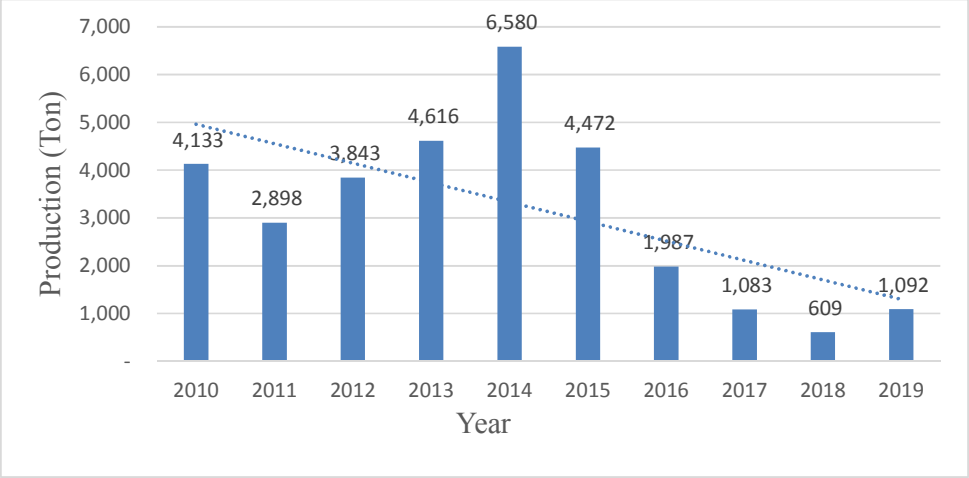

Fig. 2. Tuna Fish Production Period 2010-2019
Source: Processed Data on PPN Palabuhanratu Statistics for 2020

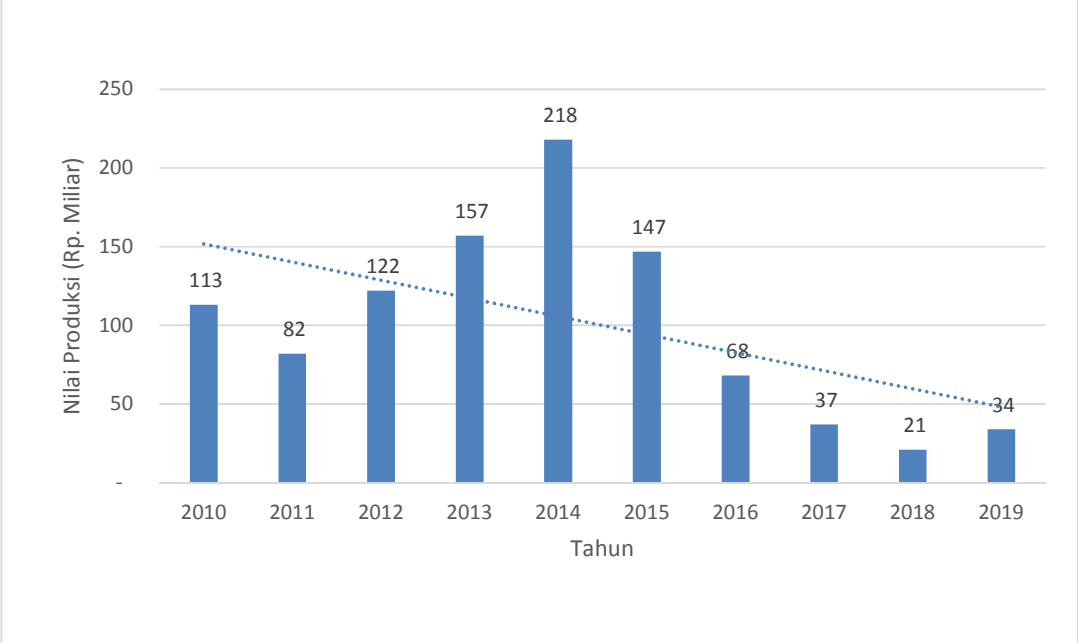

Fig. 3. Tuna Production Value for 2010-2019
Source: Processed Data on PPN Palabuhanratu Statistics for 2020

amount of production in 2016 which is equal to -55.78% (1,083 tons) from 2015, this is illustrated by the graph in the Fig. 2.

Many factors affect the value of tuna production which declined in 2015. This decline was caused by a decrease in the number of trips made by longline tuna ships. Based on previous research conducted by Hudayana and Utami [9], the decline in the number of arrests is due to the enactment of a transshipment prohibition policy, which was previously a longline tuna boat above 50 GT with a hold range of 50-70 tons can produce catches of 100 tons of fish per trip, whereas after the enactment of the transshipment ban, the catches obtained are only the size of hold.

Tuna fisheries production in PPN Palabuhanratu has fluctuated also due to the reduced number of longline tuna fishing gear that operated at PPN from 2010 which initially amounted to 160 units of fishing gear until 2019 which rreduced to only 38 fishing gear, which may have directly affected the amount of tuna production in PPN Palabuhanratu.

Based on the production (Catch) table and the production value of tuna (Table 3), it shows that the average tuna production in PPN during period 2010-2019 is 3,131 tons per year with an average tuna production value of Rp. 99,634,022,955 per year. This shows that tuna production is the main and biggest income in capture fisheries production in PPN Palabuhanratu which affects 67 % of the value of capture fisheries production that was landed at PPN during the period 2010-2019.

3.7 Production Value Index

Analysis of the production value index is obtained by comparing the value of the production of catches in a port with the value of the production of catches in one area, and the volume of production of catches in a port with the volume of production of catches in a region. The relative index of tuna production value in PPN obtained from the comparison between the volume and value of tuna production in PPN Palabuhanratu with the volume and production value of all fish in PPN for 10 years, namely from the year 2010-2019.

Table 3. Tuna Production and Production Value

Year	Production	Production Value
2010	4,133	112,691,190,000
2011	2,898	82,126,940,500
2012	3,843	121,814,979,000
2013	4,616	156,655,658,450
2014	6,580	218,067,673,600
2015	4,472	146,715,908,000
2016	1,987	67,537,544,000
2017	1,083	36,645,478,000
2018	609	20,286,335,000
2019	1,092	33,798,523,000
Align-flat	**3,131**	**99,634,022,955**
Total	**31,313**	**996,340,229,550**

Source: Processed Data on PPN Palabuhanratu Statistics for 2020

Table 4. Index of Tuna Production Value of Longline Tuna Conversation in PPN during Period 2010-2019

Year	Np / Nt	Qp / Qt	I
2010	77.8786	61.2836	1.27
2011	68,246	44.3201	1.53
2012	66,406	43,444	1.53
2013	73,398	58.2207	1.26
2014	75.6566	63,5297	1.19
2015	64,9694	49,0259	1.32
2016	63.5797	51,749	1.23
2017	45.9077	31,2076	1.47
2018	27,0183	15,339	1.76
2019	30,349	20.1619	1.51
Average			**1.41**

Source: Processed Data on PPN Palabuhanratu Statistics for 2020

Information,

I: Index relative value of production
Np / Nt: Production value of tuna / all fish in PPN Palabuhanratu (Rp)
Qp / Qt: Production of tuna / whole fish production in PPN Palabuhanratu (ton)

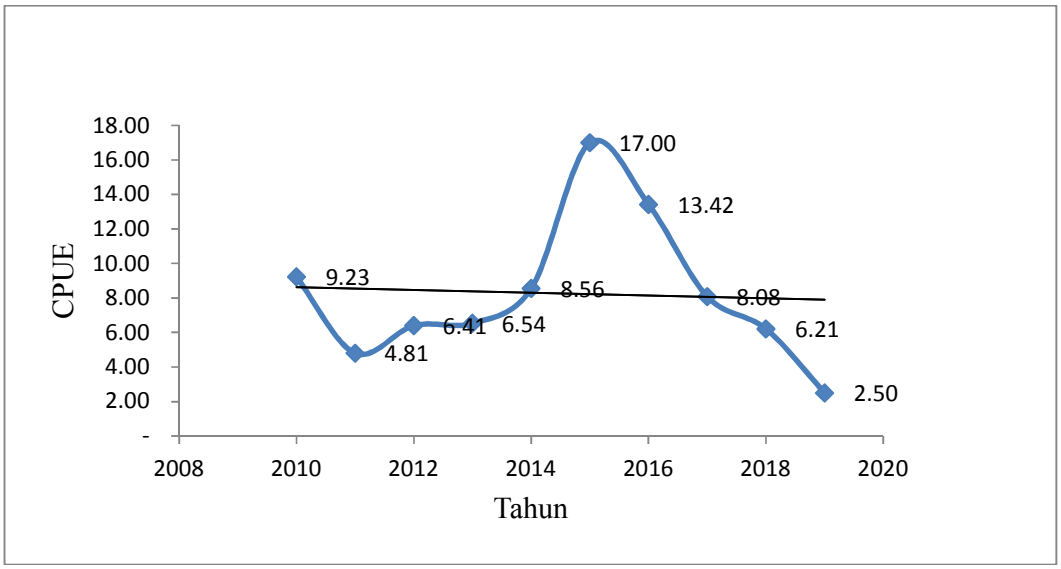

Fig. 4. CPUE Value of Tuna
Source: Processed Data on PPN Palabuhanratu Statistics for 2020

Based on the results in Table 4, the relative index of tuna production value in PPN Palabuhanratu shows the average value of 1.41, which means that the value of tuna production in PPN every year is higher than the overall production value of other fish species in PPN, and the highest production value index occurred in 2018 with a number 1.76 and the lowest in 2013, which was 1.19. This happens because the Tuna Longline ship recorded in PPN and added to ships from outside PPN which also landed their tuna catches at PPN, thus causing the tuna production at PPN Palabuhanratu to be the biggest from other fish catch production. Besides that the fishing ground / fishing ground area longline tuna ships in Palabuhanratu are also in the Indian Ocean which is a large and abundant tuna fishing area.

3.8 Maximum Sustainable Yield (MSY)

The Catch per Unit Effort (CPUE) value, reflects the ratio between the catch with the unit effort expended. The catch in principle is the output of the fishing activity, while the effort needed in principle is an input from the fishing activity. In economic terms production of a comparison between output and input reflects the level of technical efficiency of each use of inputs. Therefore, the amount of CPUE can also be used as an indicator of the level of technical efficiency of the effort. In other words, a higher CPUE value reflects a higher level of efficiency in using effort [10].

Based on Fig. 4, the CPUE value of tuna fish is relatively in a tendency to decrease, the highest CPUE value occurred in 2015 which touched 17.00 tons / trip and the lowest in 2019 which was 2.50 tons / trip. The CPUE value tends to decrease from 2015-2019, this happens because during the year there was an increase and decrease in the number of fishing efforts (effort) seen from the data of the number of trips made by longline tuna ships in PPN Palabuhanratu.

The average CPUE value in PPN in 2010-2019 is 8.28 ton / trip, and the movement of CPUE values that tend to decrease, meaning that it starts to indicate overfishing. As stated by Widodo and Suadi [11], the characteristics of capture fishery are heading to a more capturing condition including a longer sea time, a fishing location tends to be farther away, productivity / catch rate (CPUE) tends to decrease, the size of

the target fish is getting smaller, and the cost of fishing operations is increasing.

Fig. 5 produces a linear equati on y = -0.0063x + 10,924, this shows that a co nstant (a) of 10,924 states that if there is no effort, then the potential available in the real world is 10,924 kg / trip. Regression coefficient (b) of -0.0 063 states a negative relationship between prod uction and effort that every reduction of 1 trip effort w ill cause CPUE to increase by 0.0063 kg / trip, and vice versa. The coefficient of determination (R2) of 0.1376 or 13.76% stated that the rise and f all of CPUE 13.76% was influenced by the value of effort, while 86.24% was influenced by other factors not discussed in this study. Correlation coefficie nt (R) value of 0.3709, indicating that CPUE a nd effort have a low closeness.

The results of the linear regress ion calculation can be continued because the slo pe value is negative, the value is a condition for d etermining MSY and eMSY (Effort Maximum Sustainable Yield). Estimation of MSY and capture efforts obtained eMSY value of 867 trip and the value of MSY is 4737,40 Ton. The MSY curve of tuna landed in PPN Palabuhanratu can be seen in Fig. 6.

The average tuna production in PPN Palabuhanratu in the year 2010-2013 is still below the Catch Maximum Sustainable Yield (CM SY) limit, which means the catch has not exceeded the sustainable catch of 4737.40 tons. But in 2014, tuna production experienced overfishing with tuna production figures of 6,579.79 tons, that thi ng certainly has exceeded the MSY value limit. So that in 2015 fishing began in a state of decline seen with the efforts and production that is below the MSY boundary line, then the lowest point occurred in ten years in 2018 tuna production experienced its lowest point in the number 606.67 tons.

Referring to the MSY chart for m of year Schaefer model 2010-2019 shows th at tuna production in PPN Palabuhanratu has experienced overfishing, marked by the MSY graph which declined after 2014 due to the amount of pro duction that exceeds the allowed catch and eve n exceeds the MSY value limit, it is marked by a dec rease in the number of catches in subsequent ye ars.

With an MSY value of 4737.40 t ons / year, for tuna catches in PPN Palabuhanratu that are allowed to be caught (Total Allowable Catc h / TAC) is 80% of the MSY value is of 3,789.92 tons/year. If the value of fishing effort exceeds the val ue of MSY, it is expected to experience a decrease in the amount of tuna catches that have an impact on productivity or rate of catch. Conversely, if the capture effort is smaller than MSY, it is still pos sible to catch and the possibility of the results o btained will be even greater or increased.

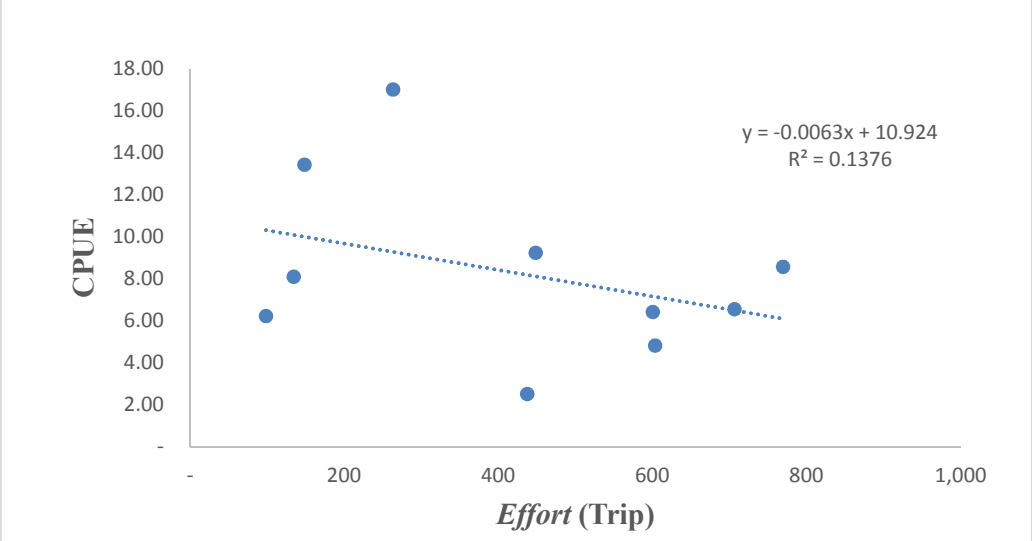

Fig. 5. Graph of Relationship between CPUE and Effort
Source: Processed Data on PPN Palabuhanratu Statistics for 2020

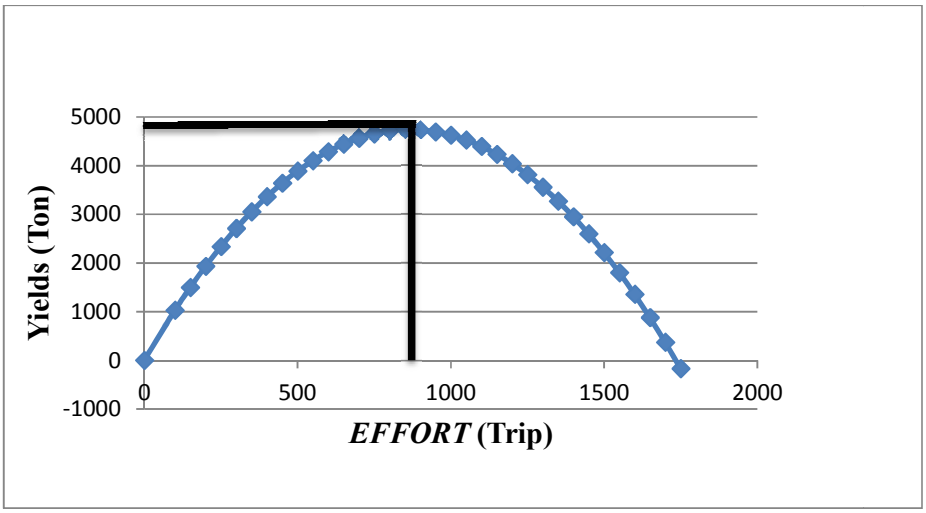

Fig. 6. MSY Schaefer Model Graph
Source: Processed Data on PPN Palabuhanratu Statistics for 2020

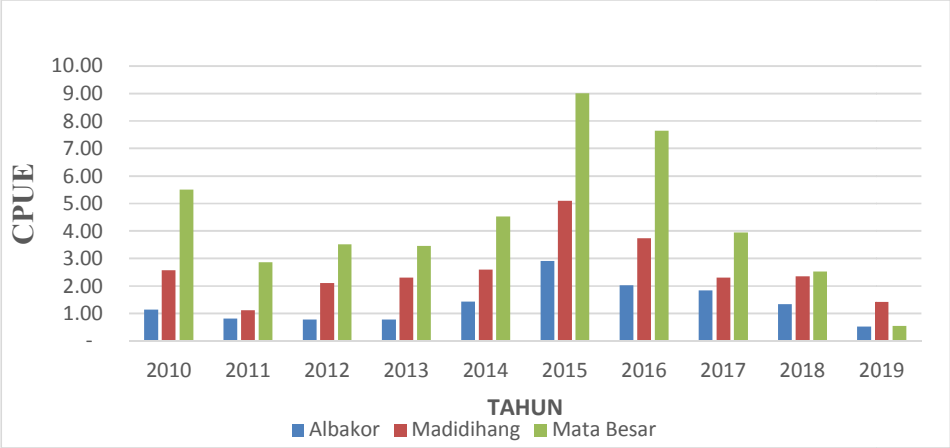

Fig. 7. CPUE Graph of Big Eye Tuna, Albakor and Yellowfin Fish
Source: Processed Data on PPN Palabuhanratu Statistics for 2020

Table 5. Total Allowable Catch with Utilization Rate

Year	Total Production	(Total Allowable Catch) TAC	Utilization Rate (%)
2010	4142.37	3789.92	109
2011	3213.07	3789.92	85
2012	4798.31	3789.92	127
2013	4931.27	3789.92	130
2014	6631.98	3789.92	175
2015	4790.95	3789.92	126
2016	1987.96	3789.92	52
2017	1083.30	3789.92	29
2018	785.71	3789.92	21
2019	1730.35	3789.92	46
Average	**3,131,33**		**90**

Source: Processed Data on PPN Palabuhanratu Statistics for 2020

The level of utilization of fish resources can be seen from the amount of fish production in a particular year compared to the value of the TAC (Total Allowable Catch) or the amount of catch allowed. The TAC (Total Allowable Catch) is 80% of the maximum potential reserve (MSY).

Based on Table 5, the Total Allowable Catch is 3,789.92 Tons / year, when viewed from the level of utilization of tuna fishery resources from the average value of catches of 3,131.33 tons, the value has not exceeded the total allowable catch and the situation is not overfishing, but the utilization rate is equal to 90% -127% which is caused by the level of utilization that is running relatively stagnant and declining, in 2010-2015 tuna fisheries production has reached 175% of the total allowable catch (TAC) per year which indicates that the state of tuna production in PPN Palabuhanratu has exceeded the Total Allowable limit Catch (TAC) in 2010-2015 which is already in saturated condition, which is automatic in the following years the production of landed tuna in PPN Palabuhanratu decreases and precisely in 2018 is the lowest production with a production of only 608.67 tons, So seen from the catch graph that fluctuates and tends to decrease in the last ten years showing indications of overfishing of big eye tuna, yellowfin and albakor in the Indian Ocean capture area.

The decline in the number of catches landed at PPN Palabuhanratu in 2016-2019 has many factors, including such as the IUU Fishing activity and the reduced number of trips and fishing gear at PPN Palabuhanratu in that year due to government regulations.

Obtained the average value of Big Eye Tuna fish CPUE is 4.36 tons / trip, then CPUE from Madidihang Tuna / Yellow fin is 2.56 tons / trip and CPUE from Tuna Albakor is 1.36 tons / trip. If we see the CPUE tuna chart (Fig. 7) that big eye tuna occupies the highest production every year in PPN Palabuhanratu by controlling 50% production and even more every year from the whole catch of tuna landed in the PPN Palabuhanratu, this is because the fishing area is WPP 573 and 573 are the fishing ground of big eye tuna and also the productivity of big eye tuna is high and fast so it causes an abundant amount compared to yellowfin tuna and albakor tuna .

4. CONCLUSION

The conclusions obtained from this research are:

The average production of the three types of tuna (Bigeye Tuna, Yellowfin Tuna and Albakor Tuna) at Palabuhanratu PPN 2010-2019 was 3,131.33 tons per year, and the production value was Rp 99,634,022,955 per year. This shows that tuna production was the main and largest income in capture fisheries production at Palabuhanratu PPN, which affected 67% of the total production value of captured fisheries landed at Palabuhanratu during the 2010-2019 period.

The relative index of the production value of the three types of tuna (Bigeye Tuna, Yellowfin Tuna and Albakor Tuna) at Palabuhanratu PPN showed an average value of 1.41 meaning that the tuna production value at Palabuhanratu PPN was higher than the overall production value types of fish in Palabuhanratu PPN, and the highest production value index occurred in 2018, namely 1.76 and the lowest in 2013 at 1.19.

The average production of the three types of tuna (Bigeye Tuna, Yellowfin Tuna and Albakor Tuna) at Palabuhanratu PPN in 2010-2019 was 5,693 tons, which reached an overfishing state, with a Total Allowable Catch (TAC) of 3789.92 tons per year. Tuna fishery production at Palabuhanratu PPN utilized tuna resources on average 90% - 127% per year. The highest CPUE value for tuna was in 2015, reaching 17.00 tons/trip and the lowest was in 2019, namely 2.50 tons/trip, with an average CPUE value of 8.28 tons/trip per year.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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