STUDY OF RESOURCES AND MANAGEMENT OF TUNA AND SKIPJACK TUNA THAT LANDED IN THE FISHING PORT OF WEST SUMATRA

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Received; April 27-2023 Received in revised from June 17-2023; Accepted July 3-2023

ABSTRACT

Tuna and skipjack are large pelagic fish with high economic value and a very wide export market. The need for and the high market demand for tuna and skipjack causes the intensity of catching these fish to increase. To ensure that the potential of these fish resources remains sustainable, it is necessary to properly manage fisheries. This study aimed to examine several biological aspects, fisheries, and aspects of utilization and management of yellowfin tuna and skipjack tuna. Data collection for yellowfin tuna was focused on one location, namely Bungus Ocean Fishing Port (OFP), while data collection for skipjack tuna was focused on 4 location points, namely Bungus Ocean Fishing Port (OFP), Carocok Terusan Coastal Fishing Port (CFP), Kambang Fish Landing Base (FLB) and Fish Landing Base (FLB). Productivity and level of effort of yellowfin tuna in West Sumatra have tended Tiku to decline in the past 4 years (2017-2020). Skipjack tuna in the West Sumatra region caught by boat charters was indicated to be overfishing, while skipjack tuna caught by troll showed the fish caught had not spawned yet. The productivity of skipjack tuna has fluctuated over the past 5 years (2016-2020).

Keywords: Fisheries management, yellowfin tuna, skipjack tuna, biological aspects, fishing season.

INTRODUCTION

Marine and fishery resources are a very large natural resource potential and receive serious attention in Indonesia. In short, two-thirds of Indonesia's territory consists of sea, has more than 17,000 islands and a coastline of 81,000 km. The 2015-2019 National Medium-Term Development Plan (RPJMN) emphasizes that the greatest focus is given to the maritime sector, which includes fisheries by optimizing the utilization of marine resources in a sustainable manner (Firdaus, 2019). Indonesian waters include deep sea waters and the EEZ (Exclusive Economic Zone) has fish resources of 12.5 million tons per year (Ministry of Marine Affairs and Fisheries (MMAF) Number 50/Kepmen-kp/2017). Over the past 5 decades, the use of these fish resources has continued to increase by an average of 5.45% annually. This is related to the advancement of fishing gear technology which is increasingly advanced and the increasing ability and number of companies and fishermen's RTP (Fishery Households) (Witomo & Wardono, 2012).

Skipjack and tuna are important commodities in the waters of West Sumatra which is included in the tuna, skipjack, and mackerel tuna (TSM) group. The average total catch of tuna and skipjack in Fishery Management Areas (WPPNRI) 572 and 573 in 2005-2016 reached 1.6 million tonnes/year (Jatmiko et al., 2020). In 2010, the export volume of tuna, skipjack, and mackerel commodities amounted to 122,450 tons with the main export destination being Japan.(Chodrijah et al., 2013). Tuna and skipjack are the main commodities to increase the industrialization of capture fisheries which has been shown by most of the coastal communities of West Sumatra who have jobs as fishermen both in the business of catching, processing, trading, and supporting industries. Therefore tuna and skipjack play an important role in enhancing fishery development in Indonesia, especially in the waters of West Sumatra(Prasetyo et al., 2018).

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Tuna and skipjack are large pelagic fish with high economic value and a very wide export market. The need for and the high market demand for tuna and skipjack causes the intensity of catching these fish to increase. This increase in fishing intensity occurred in all Indonesian territorial waters. It is feared that the high intensity of fishing will threaten the preservation and sustainability of the utilization of tuna and skipjack fish resources. To ensure that the potential of these fish resources remains sustainable, it is necessary to properly manage fisheries(Jaya et al., 2017). Even though these fishery resources can be recovered (renewable resources), the recovery speed may not be balanced with the utilization rate. If exploitation continues to occur freely (open access) without clear rules/rules of management and control, overfishing may occur or there will be an imbalance in the utilization rate.(Susaniati, 2019). Therefore, the government of West Sumatra is responsible for determining the management of fishery resources in the waters of West Sumatra for the benefit of the whole community by taking into account the sustainability and sustainability of these fishery resources (Jamal et al., 2011).

Research on the level of utilization of tuna and skipjack in the waters of West Sumatra is limited, so current information is needed regarding the status of the utilization of tuna and skipjack. This information is very much needed in efforts to manage it more sustainably.

MATERIALS AND METHODS
Method of Collecting Data

This research was carried out from March to June 2021 using the method of direct interviews with fishermen. The data obtained comes from field records made by fish landing officers at Bungus OFP, Terusan CFP, Kambang FLB, and Tiku FLB during the 2015 – 2020 period, also conducted interviews with fishermen using a questionnaire to find out the characteristics of fisheries and the efforts made by the government in management based on the results of data analysis.

Standardization of Fishing Gear

Considering the variety of fishing gear used to catch tuna and skipjack resources, namely (troll, lift net, hand line, and purse seine) in the West Sumatra region. To measure equivalent fishing gear units, standardization of effort between fishing gear is carried out using standardization techniques, namely(Susiana & Rochmady, 2018):

$$RFP_i = \frac{C_i/E_i}{Cs/Es} \quad \text{... (1)}$$

Information:
RFP_i = capture power factor of the fishing unit which will be standardized in year i
C_i = number of catches of the type of fishing unit that will be standardized in year i
Cs = number of catches of the type of fishing unit used as standard in year i
E_i = total fishing effort for the type of fishing unit that will be standardized in year i
Es = number of fishing efforts for the type of fishing unit used as standard in year i.

After obtaining the RFP_i value, to calculate the standardized fishing effort using the formula:

$$\text{Standard effort} = FPI_i \times \text{Effort} \quad \text{.......................... (2)}$$

Catch Per Unit Effort(CPUE)

The formula that can be used to determine the value of the catch per unit of fishing effort (CPUE) is as follows(Rahmawati et al., 2013):

$$CPUE_i = \frac{Catch_i}{Effort_i} \quad \text{.. (3)}$$

Where :
$CPUE_i$ = catch per unit of fishing effort in year i (tonnes/unit)
$Catch_i$ = catch in year i (tonnes)
$Effort_i$ = fishing effort in year i (unit)

Maximum Sustainable Yield (MSY)

Maximum Sustainable Yield (MSY) can be estimated using the Schaefer model with catch and effort data over several years. MSY can be estimated using the formula (Yusron, 2005):

$$\text{Catch Per Unit Effort} = \frac{\sum Y(i)}{\sum f(i)} \quad \text{............................. (4)}$$

Information:
$Y(i)$ = Catch in year i
$f(i)$ = Fishing effort in year i
i = 1, 2, ..., n

Determining 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(Mayu *et al.*, 2018):

$$f_{MSY} = -\frac{a}{2b} \text{ and } MSY = -\frac{a^2}{4b} \text{ ....(5)}$$

The management model with the MSY approach like this still has weaknesses because it is based solely on biological factors. Clark (1992) states some of the weaknesses of the MSY approach include: (1) it is not stable, because even a small estimate can lead to stock depletion, (2) it does not consider the socio-economic aspects of resource management, and (3) difficult to apply in conditions where fisheries have a diversity of species (multispecies) (Wiguna & Yuarsa, 2008). To calculate TAC (Total of allowable catch) use the following formula(Zahra *et al.*, 2014):

TAC = 80% x MSY .... (6)

According to the Minister of Maritime Affairs and Fisheries of the Republic of Indonesia No. 47 / KEPMEN-KP / 2016 the number of total allowable catches (TAC) is 80% of the maximum sustainable potential 14 which can be utilized optimally in order to realize sustainable fisheries.

Utilization Rate

To determine the level of fish resources by percentizing the number of catches in a certain year with the maximum production value (MSY)(Latuconsina, 2010):

$$\text{Utilization Rate} = \frac{Yi}{Cmay} \text{ X } 100\% \text{ ....} (7)$$

Information:
Yi = Number of catches in year – i
CMSY = Maximum Sustainable Yield

According toIrhamsyah et al. (2013), the level of utilization of fishery resources used by the commission for estimating National Marine Fish Stocks (1997) consists of four levels, namely:
1. Low level if the catch is still a small part of the sustainable yield potential (0 - 33.3%), where fishing effort still needs to be increased.
2. Moderate level if the catch has become a real part of the sustainable potential (33.3% - 66.6%) but

additional efforts are still possible to optimize yields.
3. The optimum level is when the catch has reached the share of sustainable potential (66.6% - 99.9%), additional efforts cannot increase yields.
4. The level of excess or overfishing when the catch has exceeded the sustainable potential (> 100%) and additional efforts can be dangerous to resource extinction.

After knowing the level of utilization, it is also necessary to know the level of effort. The fishing gear effort level is obtained after knowing the optimum effort level. Fishing gear effort levelcan be calculated by the formula(Listiani et al., 2017):

$$\text{Effort Rate} = \frac{Ei}{Emsy} \text{ x } 100 \text{ ....} (8)$$

Information:
Ei = first year fishing effort (trip)
EMSY = Optimum fishing effort (trip)

RESULTS AND DISCUSSION
Results

Catch Per Unit Effort (CPUE) Tuna Fish

Catch Per-Unit of Effort (CPUE) is the catch per fishing gear effort at maximum biomass conditions or is a number that describes the ratio between the catch per unit effort or effort(Setiyawan et al., 2016). The data used in this analysis is secondary data in the form of data on production and catching effort for yellowfin tuna based on capture fisheries statistics from 2016 to 2020. This data is obtained from the port where the data was collected. The fishing port which is the location for data collection is PPS Bungus.

Fishing Power Index(FPI) is a standardization of fishing gear that is carried out by calculating the value and starting with determining the standard fishing gear. Handline is used as standard fishing gear for catching yellow fin tuna, because it has a higher average Catch per Unit Effort (CPUE) compared to trolling, lift net and purse seine. Next is the standardization process by multiplying FPI with each fishing gear to get a standard effort with the results presented in table 1:

Table 1. Standardization of yellowfin tuna fishing gear

Year	*Handline*	Troll Line	Lift Net	*Purse Seine*	Standard Total Effort (standard fishing gear trip)	CPUE (tons/trips of standard fishing gear)
2016	136	9	8	24	177	2.30
2017	161	29	11	26	227	2.44
2018	142	23	6	7	177	2.74
2019	135	10	7	12	164	2.84
2020	55	18	4	18	94	2.88

Based on the standard effort data and total production that has been presented in table 1, further analysis can be carried out regarding Catch Per-Unit of Effort (CPUE). Catch Per-Unit of Effort (CPUE) is the catch per effort of fishing gear at maximum biomass conditions or is a number that describes the ratio between catches per unit of effort or effort. The following is the fluctuation of tuna CPUE in 2016-2020 presented in Figure 1:
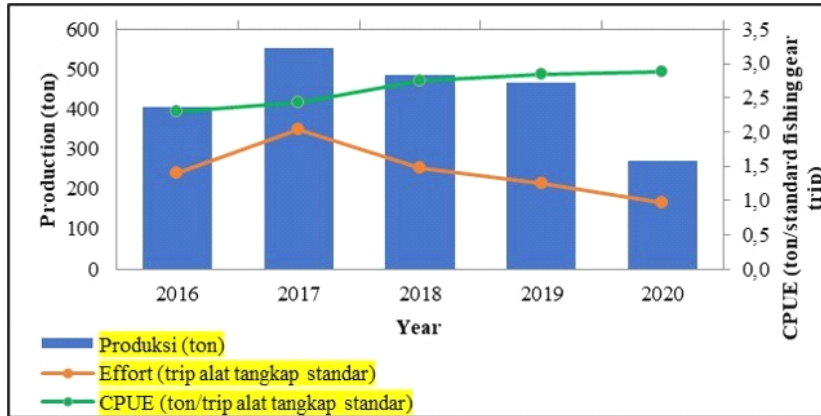

Figure 1. Development of catch production, effort, and CPUE of yellowfin tuna.

During the last 5 years, production trends have shown a level of fluctuation as shown in Figure 20. The results of the CPUE analysis in the 2016-2020 period have increased with an average value of 2.64 tons/trip of standard fishing gear. Statistical data for tuna fisheries in the West Sumatra region in brackets 2016-2020 show that the highest production yield occurred in 2017, namely 552.18 tons with an effort level of 350 trips of standard fishing gear which was the highest effort level compared to other years, and the lowest occurred in 2020 with a production yield of 271.31 tons with an effort level of 167 trips of standard fishing gear. In 2017, catch production increased, however, the addition of trips in 2017 resulted in a decrease in CPUE (figure 2).
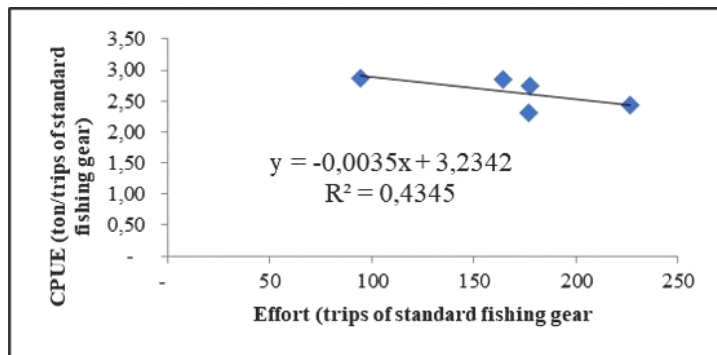

Figure 2. Relationship between CPUE and effort in the linear equation of yellowfin tuna.

Based on Figure 2, the relationship between CPUE and effort shows that the value of the estimation parameter for skipjack tuna is obtained by intercept (a) = 3.2342 and slope (b) = -0.0035 so that it forms the Schaefer linear equation, namely CPUE = -0,0035x + 3.2342. From this equation it shows that (1) the regression coefficient (b) of 0.0035 states a negative relationship between production and effort that every reduction (due to a negative sign) 1 trip will cause CPUE to increase by 0.0035 tons per tripstandard catch. However, if the effort increases by 1 trip for standard fishing gear, then CPUE is also predicted to experience a decrease in production by 0.0035 tons per trip. (2) the coefficient of determination (R2) is 0.4345 or 43.45%. This means an increase or decrease in CPUE of 43.45 which is caused by fluctuations in the effort value.

Catch Per Unit Effort(CPUE) skipjack tuna

If the CPUE trend increases, this indicates overfishing of fish in certain waters(Alimina et al., 2016). The data used in this analysis is secondary data in the form of skipjack tuna production and fishing effort based on capture fisheries statistics from 2016 to 2020. This data was obtained from the port where the data was collected. The fishing port which is the location for data collection is PPS Bungus.

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The catching power factor is obtained from secondary data on the production of fish species per type of fishing gear to calculate the catch per unit gear (CPUE), which can be seen in table 2:

Table 2. Productivity of skipjack tuna

Productivity (tonnes/trip)			
Year	*Purse Seine*	Troll Line	Lift Net
2016	1.51	1.74	1.48
2017	1.88	1.68	1.40
2018	2.70	1.46	1.36
2019	2.58	1.71	1.97
2020	1.71	1.52	1.60

Based on table 2, there are differences in fishing productivity between fishing gear by boat liftnets, troll lines and purse seine, so it is necessary to standardize fishing gear, in order to obtain the Fishing Power Index (FPI). Fishing Power Index (FPI) is a standardization of fishing gear which is done by calculating the value and starting with determining the standard fishing gear.*Fishing Power Index*skipjack tunacan be seen in table 3:

Table 3. Fishing Power Index of skipjack tuna

Index	*Purse*	Tonda	Lift Net
CPUE	2.08	1.62	1.56
FPI	1	0.78	0.75

The standard fishing gear is the fishing gear that has the highest average fishing productivity(Putra et al., 2012).*Purse seine*used as a standard fishing gear for catching skipjack tuna, because it has a high average Catch per Unit Effort (CPUE) compared to trolling gear and boat liftnets. Next is the standardization process by multiplying FPI with each fishing gear to get a standard effort with the results presented in table 4:

Table 4. Standardization of skipjack fishing gear

Year	*Purse Seine*	Troll Line	Lift Net	Standard Total Effort (tripstandard catch)	CPUE (tons/tripstandard catch)
2016	23	95	56	175	2.05
2017	25	103	50	178	2.03
2018	29	130	59	218	1.96
2019	27	91	44	163	2.37
2020	24	146	65	235	1.97

Based on the standard effort data and total production that has been presented in table 15, further analysis can be carried out regarding Catch Per-Unit of Effort (CPUE). Catch Per-Unit of Effort (CPUE) is the catch per effort of fishing gear at maximum biomass conditions or is a number that describes the ratio between catches per unit of effort or effort. The following is the fluctuation of skipjack tuna CPUE in 2016-2020 presented in Figure 3:
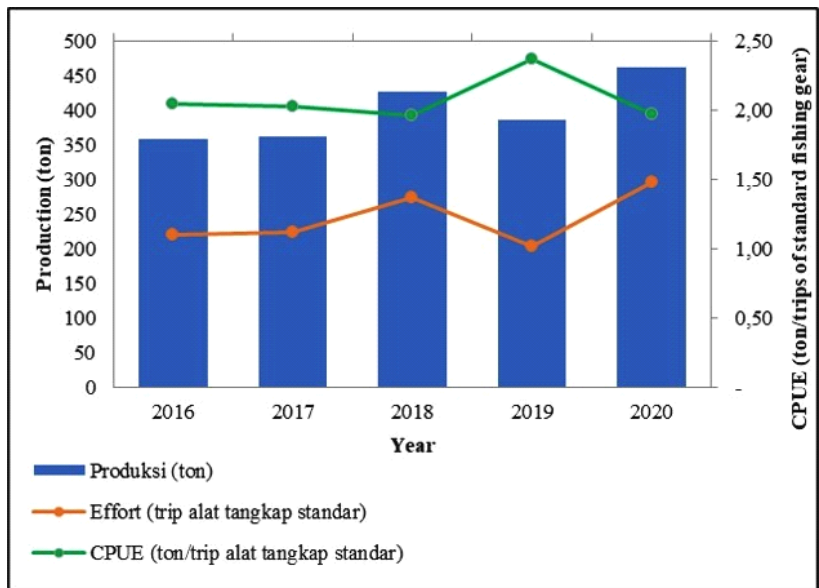
Figure 3. Development of catch production, effort, and CPUE of skipjack tuna.

During the last 5 years, production trends have shown a level of fluctuation as presented in Figure 3. The results of the CPUE analysis in the 2016-2020 period have increased with an average value of 2.08 tons/trip of standard fishing gear. Statistical data for skipjack tuna in the West Sumatra region in brackets 2016-2020 show that the highest production yield occurred in 2020, namely 462.82 tons with an effort level of 297 trips of standard fishing gear which was the highest effort level compared to other years, and the lowest occurred in 2016 with a production yield of 358.18 tons with an effort level of 220 trips of standard fishing gear. Fishing effort is related to the dimensions of fishing gear and vessels, the number of trips in operation, and the use of fishing technology(Shah et al., 2019). The fishing effort in 2016 was 220 trips for standard fishing gear then jumped in 2018 to 274 trips for standard fishing gear. Therefore, the addition of trips to the standard gear resulted in a decrease in CPUE (figure 4):
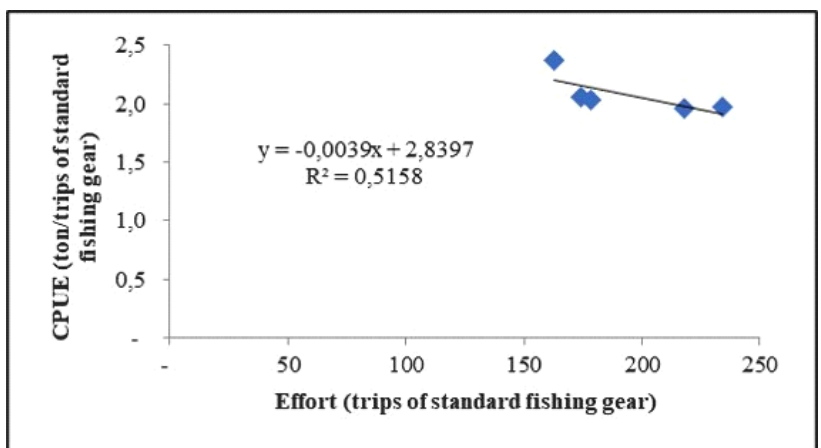

Figure 4. Relationship between CPUE and effort in the linear equation of skipjack tuna.

Based on Figure 4, the relationship between CPUE and effort shows that the value of the estimation parameter for skipjack tuna is obtained by intercept (a) = 2.8397 and slope (b) = -0.0039 so that it forms a Schaefer linear equation, namely CPUE = -0, 0039x + 2.8397. From this equation it shows that (1) the regression coefficient (b) of 0.0039 states a negative relationship between production and effort that every reduction (due to a negative sign) is 1 tripstandard fishing gear will cause CPUE to increase by 0.0039 tons per trip of standard fishing gear. However, if the effort increases by 1 trip of standard fishing gear, CPUE is also predicted to experience a decrease in production of 0.0001 tons per trip of standard fishing gear. (2) the coefficient of determination (R2) is 0.5158 or 51.58%. This means an increase or decrease in CPUE of 51.58 which is caused by fluctuations in the effort value, while the remaining 48.42% is caused by other variables not discussed in the model.

A large CPUE value is obtained from a fishing effort carried out on a high abundance of stock, on the other hand a small CPUE value is obtained from a low abundance of stock and the CPUE variability can describe the abundance index of fish in a waters (Nugraha & Hufiadi, 2012).

Maximum Sustainable Yield for Tuna

The purpose of using the production surplus model is to determine the optimum level of effort, namely the effort that can produce a maximum sustainable catch without affecting long-term stock productivity or maximum sustainable catch (Rahmawati et al., 2013). Based on yellowfin tuna production data in the last 5 years (2016 – 2020) it can be calculated

maximum sustainable yield (MSY) using the production surplus method from Schaefer, it can be seen the sustainable potential value and optimum effort of yellowfin tuna during observation so that it can be determined when overfishing occurs by comparing efforts and catches each year. The data used in calculating the maximum sustainable yield (MSY) is data for the last 5 years (2016-2020).

Based on CMSY and EMSY calculation data for tuna in the West Sumatra region using the Linear Schaefer model above, it can be seen that the MSY value is 737.54 tonnes at the optimum fishing effort (EMSY) of 456 trips. So as to form a maximum sustainable yield (MSY) curve based on the Schaefer model, the results can be seen in Figure 5:
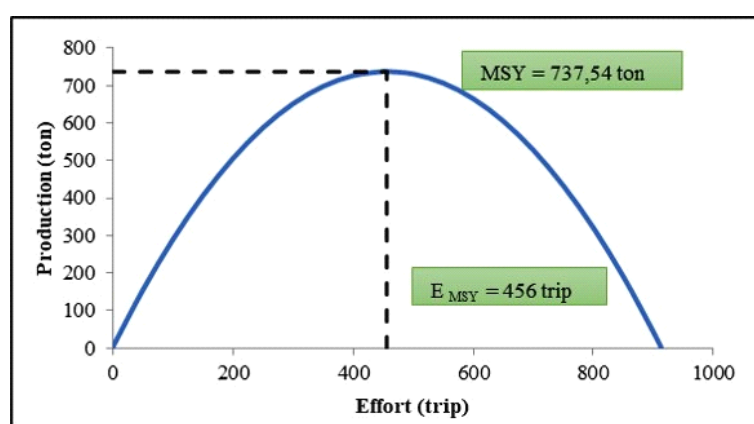

Figure 5. Maximum Sustainable Yield (MSY) curve based on Schaefer.

Based on Figure 5, the results of calculations using the production surplus method from Schaefer for the last 5 years data show that optimal utilization of yellow fin tuna resources produces a sustainable production catch (CMSY) of 737.54 tons with an optimal fishing effort (EMSY) of 456 trips, and a value of Total Allowable Catch (TAC) is 80% of the MSY value, which is 590.04 tonnes/year. So the number of catches can still be increased to the value of the Total Allowable Catch (TAC) or the Number of Allowed Catches (JTB) so that resources can be properly optimized. This model can be used as a reference standard for management, for example by regulating or limiting fishing trips to ensure the sustainability of resource use.

Maximum Sustainable Potential (Maximum Sustainable Yield) of Skipjack Fish

Maximum Sustainable Yield(MSY) is a management parameter resulting from the

assessment of fishery resources. Estimation of these parameters requires annual production catch data (time series). Based on data on skipjack tuna production in the last 5 years (2016 – 2020) it can be calculated the Maximum Sustainable Yield (MSY) with the production surplus method from Schaefer. overfishing by comparing effort and catch each year. The data used in calculating the maximum sustainable yield (MSY) is data for the last 5 years (2016-2020).

Based on CMSY and EMSY calculation data for skipjack tuna in the West Sumatra region using the Linear Schaefer model above, it can be seen that the MSY value is 512.64 tonnes at an optimum fishing effort (EMSY) of 361 trips. Thus forming a maximum sustainable yield (MSY) curve based on the Schaefer model, the results can be seen in Figure 6:
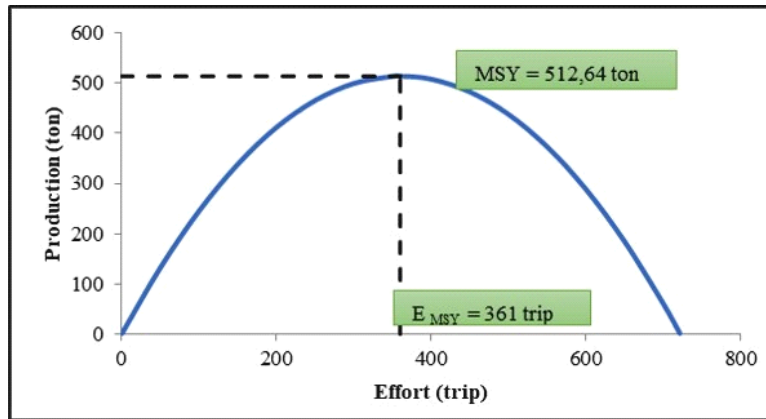
Figure 6. Maximum Sustainable Yield (MSY) curve based on Schaefer.

Based on Figure 6 the results of calculations using the production surplus method from Schaefer for the last 5 years data obtained optimal utilization of skipjack fish resources resulting in sustainable production catches (CMSY) of 512.64 tonnes with optimal fishing effort (EMSY) 361 trips, as well as a Total Allowable value Catch (TAC) is 80% of the MSY value, which is 410.11 tonnes/year. This model can be used as a reference standard for management, for example by regulating or limiting fishing trips to ensure the sustainability of resource use.

Tuna Utilization Rate

Utilization of marine fish is important to know the amount of fish that can be utilized without disturbing the fish biomass stock and can be maximized without disturbing future prospects for exploitation.(Rochmady & Susiana, 2014). The level of utilization is analyzed based on the fishing gear used. The following is the level of utilization of yellowfin tuna which can be seen in Figure 7:
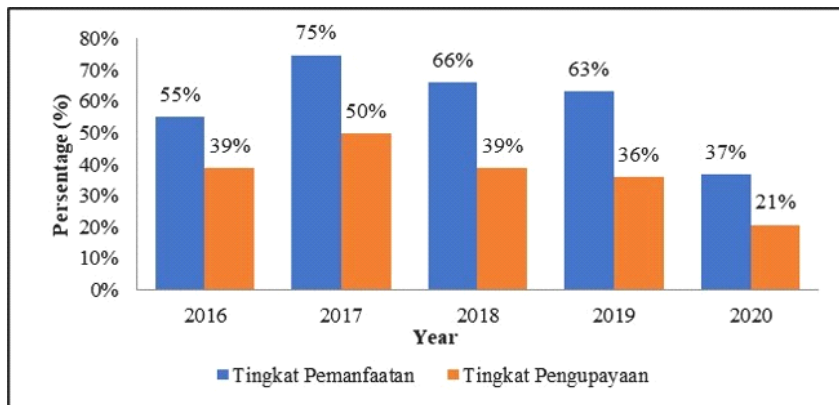

Figure 7. Utilization rate and level of cultivation of yellowfin tuna in West Sumatra.

Based on Figure 7, the value of the level of utilization of skipjack tuna in the last 5 years indicates that the level of utilization has fluctuated from 2016 – 2020. The average level of utilization of fishery resources for yellowfin tuna in the West Sumatra region is 59%. This shows that the level of utilization of tuna resources based on the estimation of National Marine Fish Stocks (1997) is in the moderate stage (33.33-66.66).

Level of Utilization of Skipjack

The level of utilization is analyzed based on the fishing gear used. The following is the level of utilization of skipjack tuna, which can be seen in Figure 8:
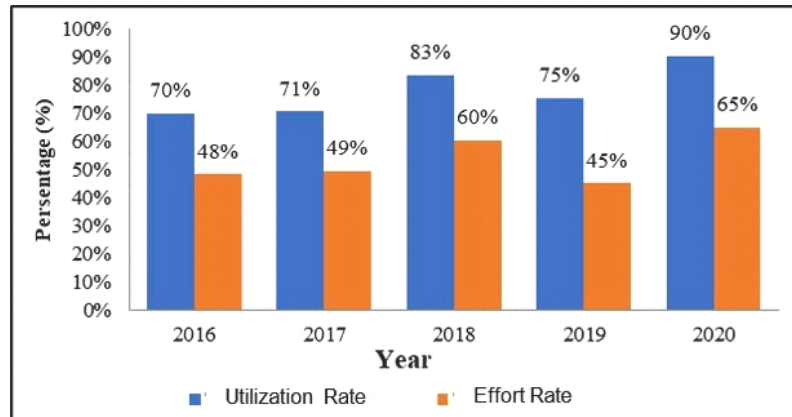
Figure 8. Utilization rate and level of cultivation of skipjack tuna in West Sumatra.

Based on Figure 8, the value of the skipjack tuna utilization rate in the last 5 years indicates that the utilization rate has increased from 2016 – 2018. The average level of utilization of skipjack fisheries resources in the West Sumatra region is 78%. This shows that the level of utilization of skipjack tuna resources based on the estimation of National Marine Fish Stocks (1997) is classified into the dense catch or optimum stage.(66.80 – 100).

CONCLUSION

Based on the maximum sustainable catch value, the total catch from 2016-2020 has not reached or has not yet approached its sustainable potential value (MSY). Therefore, it can be said that skipjack and tuna are still below the MSY value. The level of utilization of tuna resources is classified into the moderate stage while the level of utilization of skipjack fish resources is classified into the optimum stage. Tuna catch production has decreased due to low fish prices and several fishing vessels that have suffered losses. The sustainable potential of skipjack tuna shows that fishermen's catch has exceeded the total TAC catch so that if this continues it will affect skipjack fisheries resources in the future.

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