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Existence Capacity of Rays Fisheries for Fisheries Resources Management in East Nusa Tenggara Province

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ABSTRACT

Rays fishery products in the international market especially luxury products, medicine, and tonic during the last decades are quite high. Government has issued regulations to protect, to use and to trade this species but it needs understanding from all stakeholders for good application of the issued regulations especially in marine conservation zones. This research has two goals; (1) to measure the ability of the capture fleet in rays fisheries, and (2) to understand the maximum number of yields of fish during a particular period in whole use of fish stock condition. The research use secondaire data and peak to peak analysis to measure capacity utilization and fish resource management using the Schaefer model. Measurement results show that maximum yield of fishing in MSY (YMSY) is 662.75 tons, with fishing effort in MSY (FMSY) is 4,303.60 units and level of utilization (TP) is 75% includes moderately exploited. Fishing activities should still pay attention to the preservation of fish resources and the environment.

Keywords *: effort, rays fishery, trading, capacity utilization*

1. INTRODUCTION

Aquatic zone of East Nusa Tenggara (NTT) is located in Fisheries Management Area (WPP) 573 consist of Hindia Ocean spans from South of Java to Savu Sea, and western Timor Sea. East Nusa Tenggara (Nusa Tenggara Timur, NTT) Province is an archipelago with 1.192 island which 432 are named, 42 are inhibited while 1150 are uninhibited. Fishery potency is moderately high but its post yield management is 40% of long term potency as 388,7 ton per annum. Main cath are tuna, skipjack, mackarel, yellowtail scad, lobster, squid, and shell [1].

The fishing practices usually have impact on the by-catch such as on ray's and shark. The ray's, shark and skate are in sub class of *Elasmobranchii* because they are marine organisms with cartilage, 5-7 pairs of gill slits that are not covered by the operculum, and do not have a swim bladder. The species is considered commercially important and has 950 species of which 400 are shark species and the rest are rays and skates [2]. Its growth is slow with low productivity, and the risk of capture is quite high, so this species can easily become extinct in massive exploitation [3].

Information on catch composition of the *Elasmobranchii* by species, sex, frequency, size, season, depth strata, and age are still limited [4]. The fish catching very often creates the by-catch products like ray fish and shark. Ray fish production in East Nusa Tenggara Province regardless of species, size and catching tools in 2015 and 2016 are 560.33 and 279.23 tons [5]. This is similar to a research by Prabuning et al., [6] revealing that there are by-catch fish like shark and ray fish in several catching area in West Nusa Tengara (Nusa Tenggara Barat, NTB) and NTT Provinces.

The most frequently catch ray fish by fishermen are *Manta birostris*, *Manta alfredi*, *Mobula spp*., *Himanthura spp*., *Pteroplatytrygon violacea* dan *Taeniura lymma*. Ray products are sold as skin, gill racker, and meat that will be converted to wallet, belt, shoes, soft food, and medicine with export destination countries are Singapore, Hongkong, China and Japan [6].

Irresponsible and uncontrollable marine resources utilization [7] as well as the by-catch fishing are crucial problems [8]. One of the basic concepts of fisheries policy objectives is that at maximum production, the optimum exploitation rate is set to achieve MSY (Maximum Sustainable Yield), where maximum catch that can be obtained continuously (on a sustained basis). If the actual catch is less than MSY, it is called underfishing and further development can be carried out, but if the result is the other way around, it is overfishing [7].

The level of utilization (TP) of fish resources as stipulated in the Regulation of the Minister of Maritime Affairs and Fisheries Number 29 of 2012 states that the ratio between the amount of production produced and the sustainable potential can be divided into three categorie namely *over-exploited*, *fully-exploited*, and *moderately-exploited*. The level of exploitation (exploitation) of fish resources is categorized as over-exploited if the number of catches of fish resource groups per year exceeds the estimated potential set. Fish resources are categorized as fully-exploited if the number of catches of fish resource groups per year is in the range of 80% – 100% and moderate-exploited if the number of catches of fish resource groups per year has not reached 80% (eighty percent) [9].

The goals of this research are to measure ability of catch of fishing fleet on ray fishery and to understand maximum number of catchable fish during particular periods in full utilization situation with fish stock condition.

The novelty of this research lies in the measuring method of the utilization capacity of stingray fisheries in the Marine Protected Area (MPA) in the Province of East Nusa Tenggara (NTT) using the peak to peak (PtP) method. CPUE calculations using the peak to peak (PtP) method have never been done to analyze the ray fishery sector at the MPA of East Nusa Tenggara Province.

2. RESEARCH METHODOLOGY

2.1 Observation and Data Collection

The observation and data collection are done with two techniques :

1. Interview; a data collecting method by asking some clarification through prepared questioner.

2. Recording; a data collecting method by recording available data in government institutions and related organizations.

Secondary data are taken from written reports in both Central Statistic Agency (Badan Pusat Statistik, BPS) and Ministry of Marine and Fisheries from 2010 to 2018.

2.2 Analysis Method

2.2.1 Capacity utilization measurement capacity utilization with peak to peak analysis

Peak to peak (PtP) method is a common technique used to measure capacity utilization and just depend on relatively minimum data like aggregate input and product. The method is based on productivity measurement (production per unit effort) with assumption that level of peak production in particular year is considered as production in "full capacity utilization" [9].

CPUE = total catch/effort

CPUE possible (CPUEpos) is a produced CPUE if there exist an input utility in full capacity by doing a preliminary measurement from two different peak. Trend coefficient in CPUEpos is measured based on the following formula:

$$\tau = \frac{(\Upsilon p^2 - \Upsilon p^1)}{(Tp^2 - Tp^1)}$$

Where :

τ = trend

Υp^2 = CPUE in the second peak

Υp^1 = CPUE in the first peak

Tp^2 and Tp^1 = years when the two peaks exist.

In case of peak CPUE condition is not sufficient, trend coefficient could be measured through production ratio year base (Yb) with input aggregate in year base (Vb) and τ coefficient in the next years are assumed as constant. The measurement formula is :

$$\tau_b = \frac{Y_b}{V_b}$$

CU then could be measured from ration :

$$CU = \frac{NA_1 \; x \; CPUE_{\;ta}}{NA_1 \; x \; CPUE_{tpos}}$$

Where :

NA_1 = effort in year t

$CPUE_{ta}$ = actual CPUE in period t

$CPUE_{tpos}$= possible CPUE possible in period t

2.2.2 Sustainable Potency Fisheries Resource of Ray Fish Using Schaefer Model

Schaefer's model (1954) states that catch per unit effort (CPUE) and effort (f) have a negative linear relationship. Regression analysis is used to obtain information about the effect of effort (f) on CPUE which is then determined by the equation as Sparre and Venema (1999) in Rosadi (2021) [10], regarding the relationship between CPUE and effort (f) and the relationship between catches stingrays (c) with effort (f) are as follows:

Relationship between catching effort and catch yield per effort unit :

CPUE = total catch/effort (1)

U_{est} = a + (b x total effort) (2)

Since each a and b are intercept and slope from linear correlation, the result formula is :

Y_{est} = (a x total effort) + (b x (total effort^2)) (3)

The slope value (b) must be negative if the catch per unit effort (CPUE) decreases for every increase in fishing effort (f), while the intercept value (a) must be positive because the value (a) is the CPUE value obtained shortly after the ship made its first attempt to catch on a fish stock so that the equation model turns into the equation:

Y = a - bx

Then the value of Y is translated into Y/f so that it becomes the equation :

$$\frac{Y}{f} = a - bf$$

Thus becoming :

$Y = af - bf^2$ (4)

At the point of maximum fishing effort (fmax), the fish catch will be equal to zero. Maximum fishing effort (fmsy) can be calculated with Y being equal to zero and this maximum fishing effort is in half of the maximum fishing effort level (fmax). So that:

$$Y = af - bf^2 = 0$$

$$a = - bf \text{ or } f \max = -\frac{a}{b}$$

$$f_{opt} = \frac{1}{2} f \; max$$

The maximum fishing effort (FMSY) that can be done to prevent over fishing is obtained by equating the first derivative of the catch to the maximum fishing effort (FMSY) value equal to zero.

FMSY = -a / (2 x b) (5)

Maximum Sustainable Yield (MSY) can be obtained by substituting the optimum effort value (FMSY) into equation [4], so that the formula is obtained:

$$Y = \; a\left(-\frac{a}{2b}\right) - b\;\left(\frac{a}{2b}\right)^2$$

$$Y = -\frac{a^2}{2b} - \frac{a^2}{4b} \text{ or } Y = -\frac{2a^2}{4b} + \frac{a^2}{4b}$$

or C_{max} = a (-a/2b) + b (a2/4b^2)

YMSY = -(a^2)/(4 x b) (6)

UMSY = ABS (-a/2) (7)

The number of allowable catches (JTB) is calculated with the formula:

YJTB = 80% x YMSY (8)

According to Wahyudi (2010) in Listiani (2017) the utilization rate aims to determine the status of the utilization of the resources utilized [11]. The utilization rate can be calculated by dividing the average total catch divided by YJTB expressed in percent (%).

TP = Average total catch/YJTB (9)

Then, we make a graph of the Schaefer model and analyze the results through the graph about the status of fish resources that have been determined in the waters.

3. RESULTS AND DISCUSSION

MSY's sustainable potential analysis uses a production surplus model to determine the level of utilization of the stingray fishery. The sustainable catch analysis uses production and effort time series data for 10 years (2010 – 2020). The data on stingray fishery production is shown in Table 1 below:

Table 1. Ray Fishery Production Data and Number of Catch Fleet

Year	Production (tons)	Number of fleet (trips)
2010	714	5623
2011	753	3307
2012	294	4960
2013	640	5320
2014	525	5844
Year	Production (tons)	Number of fleet (trips)
2015	266	7603
2016	292	7865
2017	763	7865
2018	305.47	7865
2019	311.88	7865
2020	287.23	7865

Source: Satu Data KKP (2021)

From the data we can see that the highest ray catching number occurred in the year 2017 was 763 tons whereas the Ministry of KPRI Decision Number 4 Year 2014 on Manta Ray Fish Total Protection had been issued meanwhile the ray fish fishing is still on going. Management of fish resources must be carried out as well as possible on the basis of justice and equity in the utilization process, namely prioritizing the expansion of the workplace and improving the quality of life of the actors involved in fishery activities, and ensuring the preservation of fish resources and the environment [13].

Catching stingrays as the main target or the by-catch can be seen from the fishing season carried out by fishermen. When the main target fish (tuna) declines, stingrays can be an alternative for catching [14], so it is necessary to estimate potential as a basis for policies in the utilization and management of stingray fisheries so that the sustainability of stingray fisheries is well maintained. The CPUE value and fishery capacity utilization (CU) can be seen in Table 2 below:

Table 2. CPUE value Schaefer model

Year	Production (tons)	Number of fleet (trips)	CPUE	CPUE pos	CU	1/CU	Potential catch	Uest	Yest
2010	714	5623	0.13	0.13	0.98	1.02	730.99	0.11	600.45
2011	753	3307	0.23	0.10	2.26	0.44	333.08	0.19	627.20
2012	294	4960	0.06	0.10	0.59	1.69	496.00	0.13	647.33
2013	640	5320	0.12	0.10	1.20	0.83	532.00	0.12	625.78
2014	525	5844	0.09	0.10	0.90	1.11	584.40	0.10	577.84
2015	266	7603	0.03	0.10	0.35	2.86	760.30	0.04	273.20
2016	292	7865	0.04	0.10	0.37	2.69	786.50	0.03	208.88
2017	7.63	7865	0.00097	0.00	0.00	0.00	0.00	0.03	208.88
2018	305.47	7865	0.04	0.10	0.39	2.57	786.50	0.03	208.88
2019	311.88	7865	0.04	0.10	0.40	2.52	786.50	0.03	208.88
2020	287.23	7865	0.04	0.10	0.37	2.74	786.50	0.03	208.88

Source: Processed data

3.1 Stingray Catch

In Table 2 it can be seen that the level of effort to catch stingrays carried out by fishermen in 2010 was 714 tons and increased by 39 tons in 2011 to 753 tons. However, a decrease in production of 459 tons occurred in 2012 to 294 tons. This can be caused by environmental factors namely the existence of tides and water fertility that affect the appearance of stingrays [16].

In 2013 there was an increase in production by 346 tons to 640 tons. This aimed to meet the needs of dry gills in the Asian market [17] and the need for raw materials for Traditional Chinese Medicine (TCM) [18]. Indonesia ranks second in the world after China as an exporting country for dry gills of Manta rays which is 13% but in 2014 there was a decline of 115 tons followed by a decline in exports of dried gills in the Asian market to 2% [19].

Total production in 2015 and 2016 decreased from the previous year of 259 tons and 233 tons. respectively to 266 tons and 292 tons. This is due to the enactment of the Minister of Marine Affairs and Fisheries Decree No. 4/KEPMEN-KP/2014 concerning the Determination of the Full Protection Status of Manta Rays as protected fish species with full protection status throughout their life cycle and/or body parts. The issuance of these regulations has an impact on the decline in the production of stingrays that are caught both as by-catch and the main target.

In 2018, the production of stingrays increased from 7.63 tons to 305.47 tons as a result of the high selling price of dry gills of manta rays which reached Rp. 2,500,000.00/Kg. In 2019, there was also an increase in the number of catches made by fishermen. The price offered by the market is sufficient to make fishermen continue to carry out stingray fishing activities even though they have been repeatedly subjected to sanctions. Supervision needs to be increased especially in Marine Conservation Areas (KKP) carried out by the Government at the Regional, Provincial, Central and security forces for this type of fish catch. Rays, especially in species that are fully protected by the Indonesian government.

Table 1 can be seen that fishing lasted for several years has resulted in a decrease in the number of stingrays. This suggests that the local population may have become extinct or less as a result of fishing pressures and that the average size of the stingray caught has decreased so that fishermen have to go hunting to southern Flores [20] and conservation and law enforcement are being carried out so that this decreased capture of Manta rays [21].

3.2 Catch per Unit Effort (CPUE) of Stingray

Figure 1 shows that the catch per unit effort (CPUE) in 2010-2020 varies. The CPUE value is used to determine the tendency of the productivity of an effort (effort) in a certain time and is influenced by the level of utilization (production) and the level of effort applied [22].

Gulland in M Akoit [22] said that at the beginning of the catch there was an increase in the CPUE value due to the increase in effort and subsequently a decrease in the CPUE value. This was due to the increasing effort competition (effort) that operates where the capacity of resources was limited and tent to decrease due to continuous fishing density. This shows that in 2015, the CPUE value was 0.03 due to an additional effort of 1.759 trips from the previous year which amounted to 5.844 trips.

The addition of these efforts has an impact on the number of catches increased resulting in a decrease in the number of fisheries resources and a decrease in CPUE as an indication that the utilization of stingray resources is already high and for more details can be seen in Figure 2:

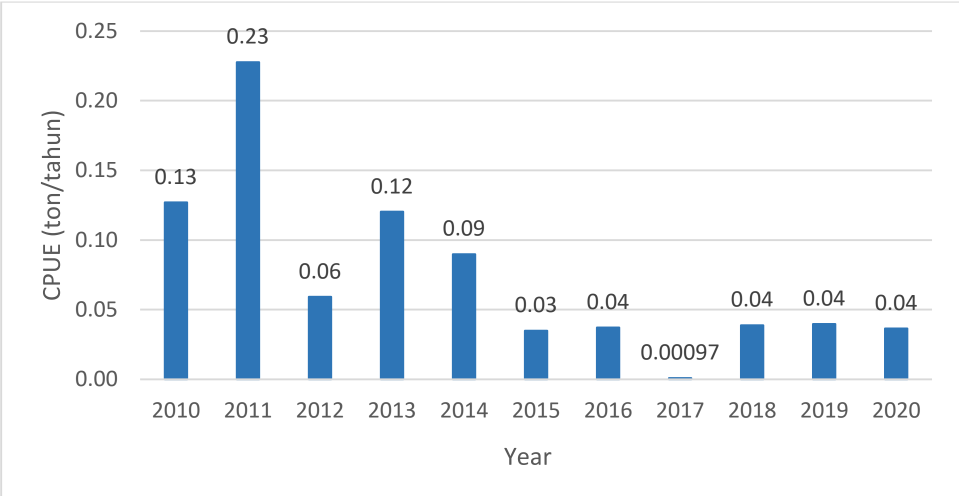

Figure 1. Development CPUE (Source : Processed data)

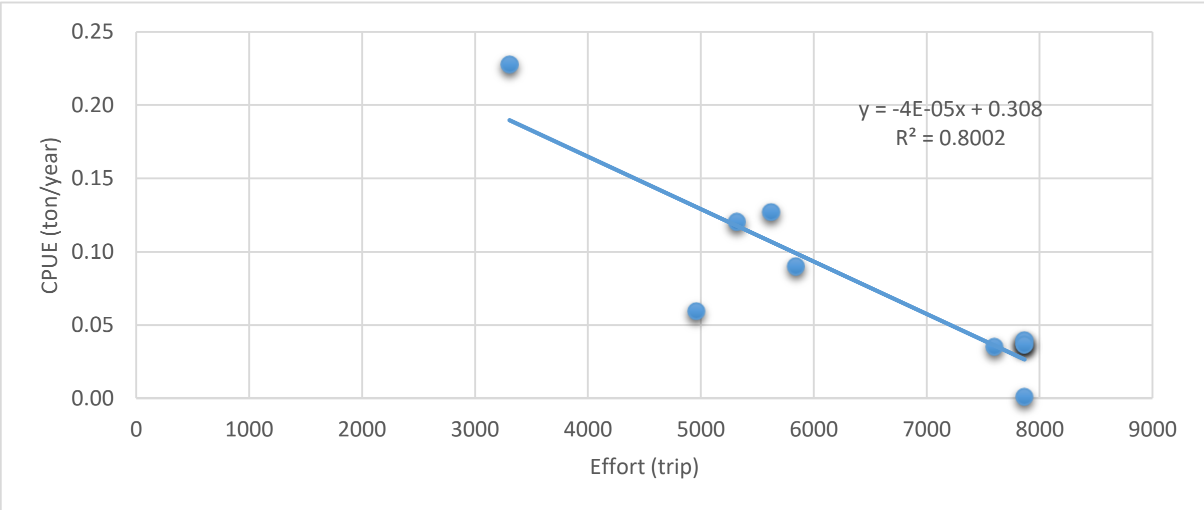

Figure 2. Relationship between CPUE and effort (Source : Processed data)

In Figure 2, the relationship between the size of the catch and the fishing effort in the Schaefer Y model = 0.308 - 4E-05x can be explained that for every increase in the catch of 1 unit of effort (trip) lower the CPUE value, which also has an impact on production decrease. The addition of an effort of 1 unit of effort (trips) will have an impact on reducing the CPUE value of stingrays by 0.00004 CPUE units (tons/trip). Based on this reality, it is necessary to control efforts so that fisheries resource management can be sustainable.

This effort level data is the basis for calculating the Schaefer model with regression analysis to find the value of ordinary least squares (OLS). The results of the regression analysis obtained the value of R^2 = 0.80 or 80% of the independent variables have a strong influence on the dependent variable. The value of determination or R^2 is used to measure the *goodness offit* of the regression model and to compare the level of validity of the regression results to the dependent variable in the model and the greater the value of R^2. The greater R2 value indicates that the model is getting better.

Based on the linear regression analysis equation, the constant a value of 0.3079 and b value of -3.57836E-05 is obtained so FMSY,YMSY, UMSY, YJTB and TP can be calculated as follows:

FMSY = -a /(2b)

=-0.3079/(2x-3.57836E-05)

= 4303.60

YMSY = -(a2)/(4b)

= -(0.30792) / (4 x -3.57836E-05)

= 662.75

UMSY = ABS (-a/2)

= ABS (-0.3079 /2)

= 0.15

YJTB = 80% x YMSY
= 80% x 662.75
= 530.20
TP = Average total catch/YJTB
= 399.66/530.20
= 0.75

The calculation above shows that the maximum catch (YMSY) is 662.75 tons with the fishing effort when MSY (FMSY) is 4.303.60 trips. The allowable catch (YJTB) is 530.20 tons and the utilization rate (TP) is 75% which is included in the *moderate-exploited* category because the number of catches of fish resource groups per year has not reached 80%.

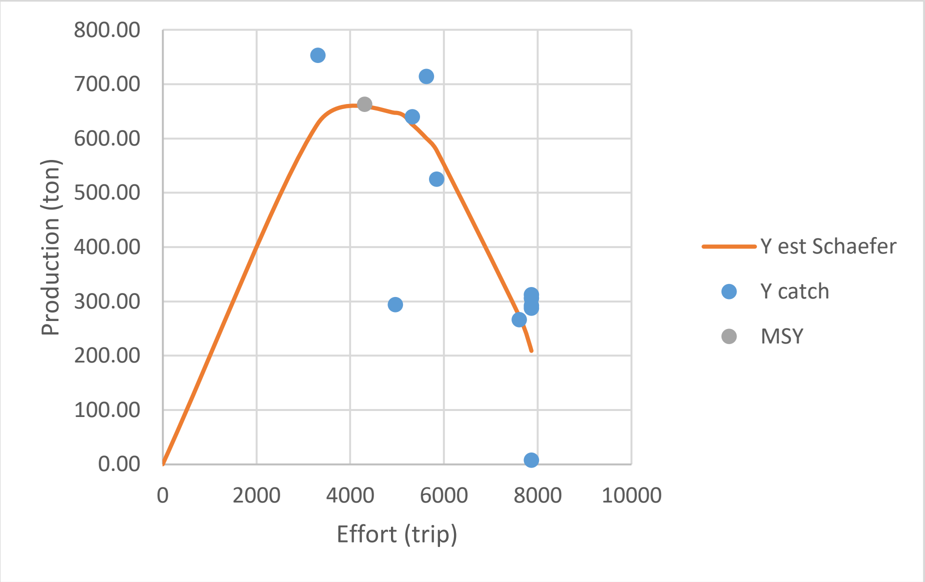

Figure 3. The CPUE relationship of the Gordon-Schaefer model of ray fisheries in NTT

The results of the above calculations can be concluded that the utilization of stingrays in 2010 and 2011 has exceeded MSY as well as the number of fishing fleets (efforts) that have exceeded the optimum effort value. The increase of the number of fishing efforts at this time is extremely not recommended although the number of production can be increased because it can destroy sustainability of stingrays resource.

Increasing the number of fishing efforts at this time is not recommended even though the amount of production can still increase because it can interfere with the sustainability of stingray resources.

Opportunities for the emergence of stingrays that occur in certain seasons can provide ecotourism potential so that stakeholders' awareness is needed so that the existence and preservation of stingrays is maintained. A well-developed ecotourism area will have many economic and ecological impact [23].

4. CONCLUSION

Stingray fishing is still happening today both as the by-catch and as the main target. The utilization rate (TP) of 75% is included in the medium exploitation category because the number of catches of fish resource groups per year has not yet reached 80%.

Government policies that have not protected all types of rays have caused many species of rays to be exploited and used to meet the short-term livelihoods of fishermen. The government needs to pay attention to the welfare of coastal communities because hunting wild animals will continue if coastal communities have not reached their level of welfare. The role of intensive aquaculture and aquaculture counseling as well as empowerment for fishing communities by utilizing their coastal areas as additional income in addition to their main job as fishermen need to be continuously developed.

AUTHORS' CONTRIBUTIONS

D.N., D.H.D., J.H.M and S.S developed the central idea of the manuscript and all authors contributed to the editing and revision of the manuscript.

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