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Sustainable potential analysis of Indian mackerel (*Rastrelligerkanagurta*) resource in East Coast waters of Aceh Province

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Abstract. Indian mackerel (*Rastrelliger kanagurta*) was among the most commonly caught fish in Aceh east coast waters. Sustainability of Indian mackerel (*R. kanagurta*) must be maintained because of its important role in improving the fisheries economy in Aceh Province. This research was conducted in east coast waters of Aceh Province from January 2019-to April 2019. Purposes of this research were to describe the general condition and to find out the sustainable management scenario of the Indian mackerel (*R. kanagurta*) fisheries in Aceh east coast waters Province. The method used was quantitative descriptive. Data collection was done by conducting interview and literature studies. The material used was on Aceh Province capture fisheries statistical data (2003–2017) obtained from Marine and Fisheries Office Aceh Province. Data were analyzed by applying surplus production and dynamic system modelling. Results indicated that utilization rate value (URy) of the fish stock was 69%. Hence the utilization status of the Indian mackerel (*R. kanagurta*) resource was moderate exploited. Based on biomass in 2017, the sustainable management scenario of the fish for the next eight years (2018-2025) would achieve the highest allocation of fishing effort equal to total allowable catch (TAC) as big as 163%. Therefore, implementation of fishing efforts equivalent to the TAC regarding the biomass sustainability can be maintained until year 2025.

1. Introduction

Aceh waters was located in two fisheries management areas (FMA), namely FMA 571 (Malacca Strait and Andaman Sea) and FMA 572 (Indian Ocean). Aceh east coast waters was part of Fisheries Management Area (FMA) 571. Legislatively, Malacca Strait lies between two countries, Indonesia and Malaysia, so that fisheries management was the responsibility of both countries, in particular for common fish stocks (*straddling and shared stocks*). Continental shelf in Malacca Strait generally has high productivity and densely populated fishing areas. Fisheries exploitation was intensively pursued by both conventional and modern fishermen [1]. The development of fisheries really needs information on the state of fish stocks, which are always renewable. It was important in view of the fact that the management of fishery resources requires up-to-date scientific knowledge. Based on clear and up-to-date scientific information sources. Patterns for the management and exploitation of

fishery resources should be formulated that can ensure the long-term sustainability of the fishing business [2].

Indian mackerel (*R. kanagurta*) was among the small pelagic fish that are the dominant commodity in Aceh east coast waters. Fishing activity to exploit small pelagic fisheries stocks in Aceh east coast waters was quite heavy which led to the occurrence of overexploited [3]. Therefore, it is necessary to know the specific conditions and provide sustainable management of Indian mackerel (*R. kanagurta*) in Aceh east coast waters hence lead to economic stimulation for fishing community in Aceh east coast waters.

2. Methods

2.1. Research Methods

This research was performed using quantitative descriptive methods. Quantitative descriptive method is a scientific method or scientific because it meets concrete scientific principles or empirical, objective, measurable, rational and systematic, so that the results in the form of a description, systematic, factual and accurate description of facts, properties and relationships between the Phenomena based on the stored data [4]. This research was conducted from January to April 2019 at Marine and Fisheries Office of Aceh Province. Primary data used was direct documentation and results of interviews with Aceh Marine and Fisheries Office staff who handle capture fisheries data. The interview was expected to gather information in the form of data validation processes and other required information. As secondary data, statistical data on catch fishing in Aceh east coast waters was used for a period of 15 years, from 2003 to 2017. The data used include catch data of Indian mackerel (*R. kanagurta*) in Aceh east coast waters in tonnes, capture effort according on the type of fishing gears in Aceh east coast waters in trip, and catch data according type of fishing gears in Aceh east coast waters in tonnes. Other secondary data also used in this research are scientific articles, books, scientific journals, and stock assessment documents.

2.2. Data Analysis

2.2.1. Fishing Gears Standardization. Fishing gears in Indonesia has characteristics as multi-gear and multi-species. This means that one fishing gear can catch many species of fish and one species can be caught by a variety of high productivity gear. Therefore, it was necessary to standardize the gear. Steps of calculation to be taken to standardize the gear are: 1) Catch and fishing effort every year; 2) CPUE (productivity) of each fishing gear, 3) Fishing Power Index (FPI), and 4) Value of a standardized fishing effort (standard effort) for each fishing gears using several formulas as follow [5] :

$$CPUE = \frac{Catch}{Effort} \quad (1)$$

$$FPI_i = \frac{CPUE_i}{CPUE_s} \quad (2)$$

$$F_s = FPI_i \times F_i \quad (3)$$

Where:

CPUE : catch per fishing gear effort (ton/trip),

Catch: amount of fish caught (ton),

Effort: amount of fishing effort (trip)

FPI_{*i*}: fishing power index of fishing gear *i*,

CPUE_{*i*}: catch effort of fishing gear *i* (ton/trip)

CPUE_{*s*}: the highest catch effort (ton/trip)

F_s: fishing effort standard, and
 F_i: fishing effort amount fishing gear *i*.

2.2.2. *Sustainable Potential Analysis of Schaefer's Model.* Catch determination was carried out according to the method of surplus production with the Schaefer 1954 equilibrium model which follow parabolic equation namely $Y = a + b f^2$. The form of this equation model has then been derived linearly become the following formula [5].

$$Y/f = a + 2bf \quad (4)$$

Where:

Y: amount of catch (ton),

a : intercept

b : slope of imaginary line performed by CPUE and effort plotting

The maximum sustainable fishing effort (E_{msy}) can be calculated using the following formula:

$$E_{msy} = -\frac{a}{2b} \quad (5)$$

Calculation the maximum sustainable catch (Y_{msy}) using the following formula:

$$Y_{msy} = -\frac{a^2}{4b} \quad (6)$$

The value of a was the intercept and the value of b was the slope of the linear equation, so that the value of Catch by Unit Effort (CPUE) in the Maximum Sustainable Yield (MSY) condition can be calculated using the following formula:

$$U_t = \frac{Y_{msy}}{E_{msy}} \quad (7)$$

Where:

U_t was catch by effort (tons/trips),

Y_{msy} was a catch by year (tons), and

E_{msy} was a catch effort by year (trips).

2.2.3 *Total Allowabel Catch (TAC) Estimation.* Total Allowable Catch (TAC) of 80% of the maximum sustainable yield (MSY). If TAC < MSY means the fishing effort has not exceeded the limit of sustainable stocks in the waters, so that the fishing effort was increased to get maximum results but still based on the MSY limit that has been calculated. The TAC calculation uses the Schaefer 1954 model with the following equation [6].

$$TAC = 0.8 \times Y_{msy} \quad (8)$$

The estimation of the TAE value using the Schaefer 1954 model was made according to the following formula.

$$TAE = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \quad (9)$$

Where:

TAE the number of fishing gear trips allowed,

a: an intercept in the regression equation,

b: was a slope in the regression equation, and

c :TAC.

2.2.4. *Estimation of utilization status.* The management of fish stocks in was important in order to know the level and status of the use of fish stocks in those waters. This utilization rate can be determined from the value of the comparison between the actual production and the potential value of the total allowable catch (TAC) as a reference. The level of utilization of fishery resources was equated as follows [7].

$$URy = \frac{Ci}{TAC} \times 100\% \quad (10)$$

Where:

URy: represents utilization rate (%),
Ci was the average total catch (tons), and
TAC was total allowable catch (ton).

The basis for determining the status of use of fish stocks used in this study is divided into three categories [8]:

1. Moderate-exploited, if the number of fish catches by year has not reached 80% of the estimated fixed potential.
2. Fully-exploited, if the quantity of fish catches by year is between 80%-100% of the estimated potential.
3. Over-exploited, when the quantity of catches by year exceeds the estimated fixed potential (> 100%)

2.2.5. *Estimation of Sustainable Stocks.* Potential of sustainable stocks (Be) in an area can be calculated using the Walter Hilborn 1976 model, model one and model two. The Walter Hilborn 1 model uses a simple differential equation [9]. The equation can be written as follows:

$$\frac{U_{t+1}}{U_t} - 1 = r - \frac{r}{Kq} U_t - qEt \quad (11)$$

where $a = r$, $b = \frac{r}{Kq}$, dan $c = q$ was the parameter estimator of the multiple regression coefficient.

Frequently found errors in the estimated parameters for r and q , which are negative, then Walter Hilborn 1 modified the above equation into the Walter Hilborn 2 equation [10]. The equation can be written as follows:

$$U(t + 1) - U_t = r \times U_t - \frac{r}{Kq} U_t^2 - q \times U_t \times Ft \quad (12)$$

Walter Hilborn model can provide an estimate of the individual parameters of the overproduction function, namely the intrinsic growth rate (r) of fish, including the length, weight and maturity of the gonad, the catch coefficient (q), namely the number of efforts to catch a resource and natural environmental impact (k), namely the ability of fish resources to renew themselves [11]. The equation can be written as follows:

$$B_{t+1} = B_t + r \times B_t \left(\frac{B_t}{K} \right) \times \left(1 - \left(\frac{B_t}{K} \right) \right) - Y_t \quad (13)$$

The method of the Walter Hilborn 1976 model is as follows:

$$Y_t = q \times X_t \times Ft$$

$$B_t = \frac{C_{pUEt}}{q}$$

So that $C_{pUEt} = Y_t/F_t$, which specifies the value of Catch by Unit Effort (C_{pUE}). The basic equation of the production surplus model can be formulated as follows:

$$\frac{C_{pUE+1}}{1} = \left(\frac{rB_t}{q}\right) + \left(\frac{rC_{pUEt}}{q}\right) \times \left(1 - \frac{C_{pUEt}}{Kq}\right) - C_{pUEt} \times F_t \quad (14)$$

Where:

- B_{t+1} : Stocks of biomass in year $t + 1$
- B_t : Stocks of biomass in year t
- Y_t : Catch in year t
- q : Capability of fishing gears
- r : Intrinsic growth rate
- K : Carrying capacity of the environment

2.2.6. *Dynamic System Modeling.* STELLA 9.0.2 was software designed to increased the effectiveness of a set of processes for displaying, simulating, analyzing and communicating a desired model. The purposes of STELLA were to accelerated and enriched the process of building a model to be more reliable and effective [12].

The STELLA 9.0.2 modeling, the value of r (intrinsic growth rate) or growth rate and K (storage capacity) or the maximum environmental carrying capacity of biomass uptake affect the production volume. While the q -value directly affects the number of catches obtained (catch). The value of the biomass (stock) is influenced by the level of the production value (P_d fish), the number of catches (catch) and the value of the biomass (stock) in the previous year [13] (Figure 1).

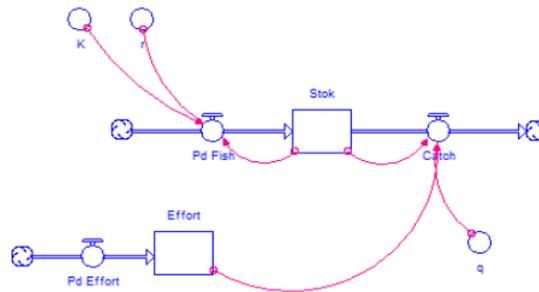


Figure 1. Modeling biomass stocks with STELLA 9.0.2 application

3. Result

3.1 General Condition of Research Location

The province of Aceh is a special region on the western end of the island of Sumatra between $2^{\circ}00'00'' - 6^{\circ}04'30''$ N and $94^{\circ}58'34'' - 98^{\circ}15'03''$ E. The Aceh east coast waters Province consists of eight districts/cities where catch are landed. The eight regencies/towns include North Aceh Regency, East Aceh Regency, Bireun Regency, Aceh Tamiang Regency, Pidie Regency, Pidie Jaya Regency, Langsa City and Lhokseumawe City (Figure 2).

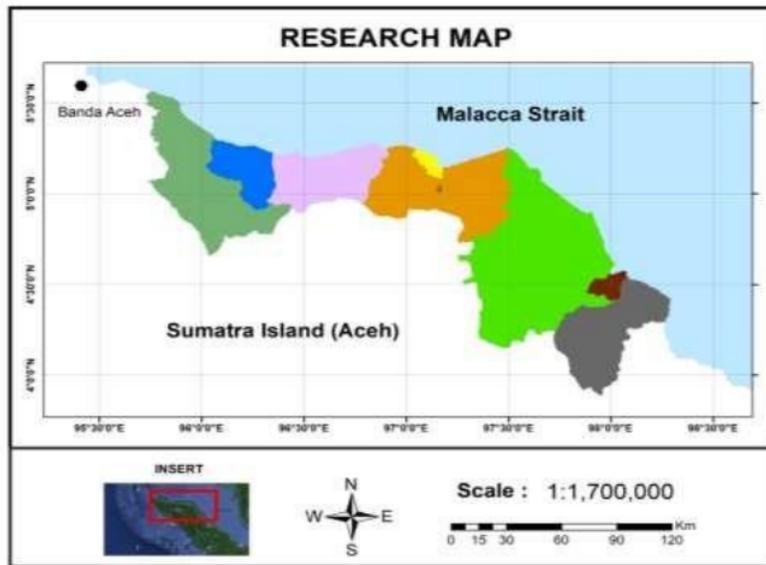


Figure 2. Research map (the Aceh east coast waters Province)

3.2 Catch of Indian mackerel (*R. kanagurta*)

Based on statistical catch data in Aceh east coast waters (2003-2017), Indian mackerel (*R. kanagurta*) had the highest production of 19,795 tons in 2016 and the lowest production of 698 tons in 2017. According to fishing gear used, In 2016, purse seine produced the highest contribution with catch as much as 12,349 tons while raft net gave the lowest contribution with no catch was obtained (Table 1).

Table 1. Catch of Indian mackerel (*R. kanagurta*) in fishing gears at Aceh east coast waters (2003 – 2017)

Years	Purse seine	Lampara	Beach seine	Raft net	Set gillnet	Drift gillnet	Encircling gillnet	Total
2003	1762.2	559.7	428.7	95.1	551.2	501.4	448.8	4346.99
2004	1311.6	525.3	259.7	52.6	153.8	279.5	100.6	2683.13
2005	1754.1	850.8	902.7	131.3	434.9	1003.0	271.7	5348.43
2006	4033.7	654.7	735.0	168.8	559.1	1379.3	541.4	8071.99
2007	4104.2	322.7	197.4	101.4	432.4	1464.6	134.2	6756.99
2008	3126.8	303.1	24.0	50.6	375.4	1007.3	291.3	5178.38
2009	2942.5	204.8	52.4	0.0	71.8	1179.1	560.1	5010.67
2010	3446.1	339.6	74.9	47.3	373.8	1311.8	609.5	6203.04
2011	6292.1	327.6	261.5	41.4	994.9	2035.9	946.7	10900.08
2012	6274.2	58.9	375.1	0.0	1278.2	1701.0	791.7	10479.03
2013	5881.6	32.7	226.6	0.0	1286.7	1219.5	781.1	9428.20
2014	6926.0	68.9	438.8	0.0	964.9	1865.1	209.6	10473.33
2015	10360.2	0.0	71.8	0.0	3313.5	1331.9	2727.1	17804.52
2016	12349.0	68.7	475.7	0.0	2701.6	2560.4	1640.0	19795.50

Years	Purse seine	Lampara	Beach seine	Raft net	Set gillnet	Drift gillnet	Encircling gillnet	Total
2017	421.1	1.2	10.0	0.0	112.1	71.8	81.6	697.87

3.3 Fishing Gear Productivity of Indian mackerel (*R. kanagurta*)

The Aceh east coast waters has a lot of fishing gears that catch Indian mackerel (*R. kanagurta*). But only seven types of fishing gear with a high catch rate with purse seine as dominant fishing gear (Table 2).

Table 2. Total fishing effort in Aceh east coast waters (2003 – 2017)

Years	Purse seine	Inc. Lampara	Beach seine	Raft net	Set gillnet	Drift gillnet	Encircling gillnet
2003	291244	64536	137203	14640	256040	197989	69030
2004	177757	60971	32679	8400	162260	133416	35168
2005	84762	50868	51282	2376	154950	124074	74052
2006	35280	24024	69720	16368	573744	937032	123876
2007	30336	14256	47664	13608	371616	743736	83268
2008	57012	14256	8856	13608	329376	714432	123588
2009	65808	31416	5832	0	54888	347640	196584
2010	92484	32472	14688	13608	336864	857952	251676
2011	74846	17402	9761	6804	195834	490723	133517
2012	57208	2332	4834	0	54805	123494	15358
2013	50018	1166	3798	0	54662	80380	14342
2014	46824	2332	2965	0	9668	120344	2032
2015	53212	0	4632	0	99656	40417	26652
2016	40145	0	3498	0	75035	30489	20001.5
2017	27079	0	2364	0	50415	20561	13351

Productivity of Indian mackerel (*R. kanagurta*) was obtained from the production of fishing gears (Table 1) divided by the fishing effort (Table 2). Based on the results of the division, the highest Indian mackerel (*R. kanagurta*) in 2016 was a total productivity of 0.645 tons/trip. While the lowest productivity was in 2017 with a total productivity of 0.032 tons/trip (Table 3).

Table 3. Productivity of Indian mackerel (*R. kanagurta*) fishing gear in Aceh east coast waters (2003 – 2017)

Years	Purse seine	Lampara	Beach seine	Raft net	Set gillnet	Drift gillnet	Encircling gillnet
2003	0.006	0.009	0.003	0.006	0.002	0.003	0.007
2004	0.007	0.009	0.008	0.006	0.001	0.002	0.003
2005	0.021	0.017	0.018	0.055	0.003	0.008	0.004
2006	0.114	0.027	0.011	0.010	0.001	0.001	0.004
2007	0.135	0.023	0.004	0.007	0.001	0.002	0.002
2008	0.055	0.021	0.003	0.004	0.001	0.001	0.002
2009	0.045	0.007	0.009	0.000	0.001	0.003	0.003
2010	0.037	0.010	0.005	0.003	0.001	0.002	0.002
2011	0.084	0.019	0.027	0.006	0.005	0.004	0.007

Years	Purse seine	Lampara	Beach seine	Raft net	Set gillnet	Drift gillnet	Encircling gillnet
2012	0.110	0.025	0.078	0.000	0.023	0.014	0.052
2013	0.118	0.028	0.060	0.000	0.024	0.015	0.054
2014	0.148	0.030	0.148	0.000	0.100	0.015	0.103
2015	0.195	0.000	0.015	0.000	0.033	0.033	0.102
2016	0.308	0.000	0.136	0.000	0.036	0.084	0.082
2017	0.016	0.000	0.004	0.000	0.002	0.003	0.006

3.4 Standardization of Fishing Gears

The calculation of Fishing Power Index (FPI) of Indian mackerel (*R. kanagurta*) fishing gear in 2003-2017 shows that the standard fishing gear was purse seine, because it has high productivity (dominant) and value of FPI was 1. The calculated FPI value was then used to calculate standard effort with multiplying FPI value of each fishing gear by the trips total of each fishing gear (Table 4).

The calculation results of Indian mackerel (*R. kanagurta*) standard effort in 2003-2017 have confirmed development of Indian mackerel (*R. kanagurta*) standard effort in 2003-2017. Based on a total of seven fishing gear used, the highest effort occurred in 2003 of 445983 trips. Then the lowest effort occurred in 2017 of 43399 trips. The total effort of this standard fishing gears would be used to estimated the sustainable potential of Indian mackerel (*R. kanagurta*) (Table 5).

Table 4. FPI calculation results of Indian mackerel (*R. kanagurta*) fishing gears in Aceh east coast waters (2003-2017)

Fishing Gears	Average (ton/trip)	FPI
Purse seine	0.093	1.00
Inc. Lampara	0.015	0.16
Beach seine	0.035	0.38
Raft net	0.007	0.07
Set gillnet	0.016	0.17
Drift gillnet	0.013	0.14
Encircling gillnet	0.029	0.31

Table 5. Standard effort of Indian mackerel (*R. kanagurta*) in Aceh east coast waters (2003-2017)

Years	Purse seine	Inc. Lampara	Beach seine	Raft net	Set gillnet	Drift gillnet	Encircling gillnet	Total
2003	291244	10334	51821	1037	43018	27127	21402	445983
2004	177757	9764	12343	595	27262	18280	10903	256903
2005	84762	8146	19369	168	26033	17000	22959	178437
2006	35280	3847	26333	1160	96396	128385	38407	329807
2007	30336	2283	18002	964	62436	101901	25816	241739
2008	57012	2283	3345	964	55339	97886	38317	255146
2009	65808	5031	2203	0	9222	47631	60949	190843
2010	92484	5200	5548	964	56597	117550	78030	356373
2011	74846	2787	3687	482	32902	67235	41396	223335
2012	57208	373	1826	0	9208	16920	4762	90297
2013	50018	187	1435	0	9184	11013	4447	76283
2014	46824	373	1120	0	1624	16489	630	67060

Years	Purse seine	Inc. Lampara	Beach seine	Raft net	Set gillnet	Drift gillnet	Encircling gillnet	Total
2015	53212	0	1749	0	16743	5538	8263	85506
2016	40146	0	1321	0	12607	4177	6201	64452
2017	27079	0	893	0	8470	2817	4139	43399

3.5 Sustainable Potential Analysis of Schaefer's Model

Estimation of the sustainable potential of Indian mackerel (*R. kanagurta*) with the Schaefer 1954 model using standard data catch and effort. Then the CPUE value was calculated by dividing catch and effort. The highest yield of Indian mackerel (*R. kanagurta*) CPUE was obtained in 2016 of 0.307 tons/trip and the lowest in 2017 of 0.016 tons/trip (Table 6).

Table 6. Standard effort, catch and CpUE of Indian mackerel (*R. kanagurta*) in Aceh east coast waters Province

Years	Effort (trips)	Catch (tons)	CPUE
2003	445983	4347	0.010
2004	256903	2683	0.010
2005	178437	5348	0.030
2006	329807	8072	0.024
2007	241739	6757	0.028
2008	255146	5178	0.020
2009	190843	5011	0.026
2010	356373	6203	0.017
2011	223335	10900	0.049
2012	90297	10479	0.116
2013	76283	9428	0.124
2014	67060	10473	0.156
2015	85506	17805	0.208
2016	64452	19795	0.307
2017	43399	698	0.016
Average	193704	8212	0.076

The calculation results of sustainable potential analysis in Schaefer model showed a utilization value of Indian mackerel (*R. kanagurta*) was 69% (Table 7). While the shape of the curve resulting from Schaefer model analysis was a parabolic curve. The parabolic curve was obtained from the equation $y = af + bf^2$. The curve was obtained from the value of the fishing effort in 2003-2017 which has been sorted from minimum to maximum with catches of Indian mackerel (*R. kanagurta*). The catch of Indian mackerel (*R. kanagurta*) in Aceh east coast waters Province has fluctuations that tend to decreased (Figure 3).

Table 7. Result of sustainable potential estimation analysis of Indian mackerel (*R. kanagurta*) in Aceh east coast waters

Variabel	Indian mackerel (<i>R. kanagurta</i>)
R square	0.41

Intercept	0.16
X Variable 1	-4.64E-07
Emsy	178865
Ymsy	14858
Umsy	0.08
TAC	11886
TAE	74088
Utilization rate	69%
Significance f	0.01
α	0.05

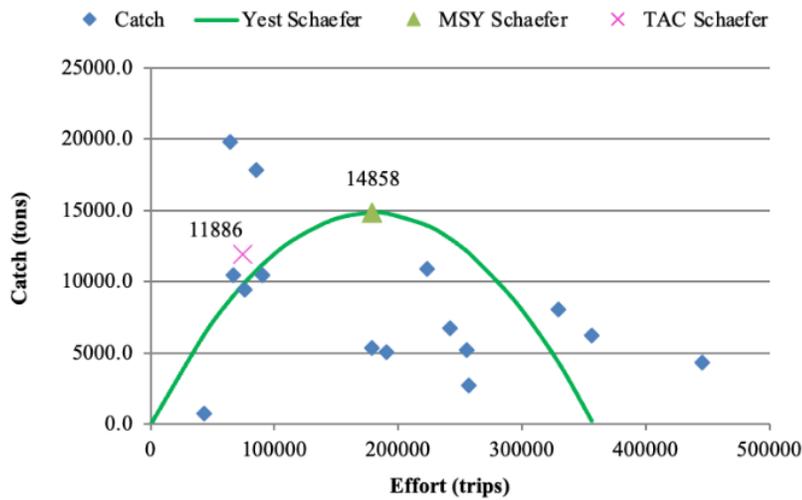


Figure 3. Relationship curve between effort and catch of Indian mackerel (*R. kanagurta*) in Aceh east coast waters Province

3.6 Estimation Value of Sustainable Stock Potential and Biomass Stock in 2017

Based on the coefficient of determination (R^2), the value estimation of sustainable biomass stocks of Indian mackerel (*R. kanagurta*) in Aceh east coast waters used analysis results of Walter-Hilborn 1976 model of two model. In addition, the values of r , k and q are used to stock estimation scenario of Indian mackerel (*R. kanagurta*) (Table 8).

Table 8. The analysis results of Indian mackerel (*R. kanagurta*) Walter-Hilborn 1976 model

Variable	Walter-Hilborn 1	Walter-Hilborn 2
R square	19%	73%
r	0.29	0.47
K	463881	57054
q	2.93E-06	1.16E-06
Be	231941	28527

3.7 Management scenario of Indian mackerel (*R. kanagurta*)

The management scenario of Indian mackerel (*R. kanagurta*) in Aceh east coast waters uses three alternatives. Among the alternatives used was the execution of catch effort, which corresponds to the effort in 2017 of 43399 trips/year, implementation of maximum sustainable fishing effort (Emsy) of 74088 trips/year, and implementation of total allowable catch of 17885 trips/year. Based on these three alternatives, the best potential outcomes of biomass stocks are achieved by implementing a catch effort equal to the allowable fishing effort (Table 9).

Table 9. The estimation biomass stock of Indian mackerel (*R. kanagurta*) used allowable fishing effort

Year	Biomassa (tons)	Be (tons)	Biomass Stocks (Biomassa/Be)
2017	40323	28527	141%
2027	46599	28527	163%

Based on the modeling of biomass stocks with an alternative allowable catchment (Ftac) of 74088 trips/year, the remaining biomass stocks would be increased until 2025. In addition, the catch was increased every year (Figure 4).

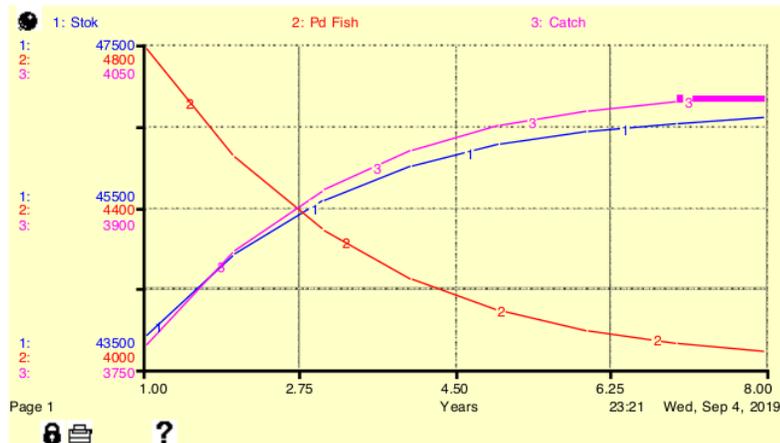


Figure 4. The modeling biomass stocks of Indian mackerel (*R. kanagurta*) with alternative total allowable fishing effort (TAE)

4. Discussion

Based on capture fisheries statistics in Aceh east coast waters, mainly Indian mackerel (*R. kanagurta*) was caught as species of small pelagic fisheries. The catch of Indian mackerel (*R. kanagurta*) was possible in each district/city belonging to Aceh east coast waters. Therefore, renewable information was needed on the condition of fisheries stocks and its management options. This is done so that the resources of Indian mackerel (*R. kanagurta*) were sustainable and become the economic driving forces of the people in the northern and eastern regions of Aceh province

Geographically, the province of Aceh was located on the northern tip of Sumatra Island and flanked by two marine ecosystem areas, Malacca Strait and the Indian Ocean. There are eight districts/cities bordering the Straits of Malacca and ten districts/cities bordering the Indian Ocean.

This condition has made this province a great opportunity to develop the fisheries sector, especially catch fishing. Backward linkages could be developed by building a fishing boat industry and fishing gear manufacturing industry [14].

Kind of fishing gear used to exploit Indian mackerel (*R. kanagurta*) was obtained from interviews with marine and fisheries office staff of Aceh Province. Based on interviews, there were seven fishing gear that produce catches of Indian mackerel (*R. kanagurta*) in Aceh east coast waters namely purse seine, lampara, beach seine raft net, set gillnet, drift gillnet, and encircling gillnet. Indian mackerel (*R. kanagurta*) which has the highest productivity was purse seine. The cause was that purse seiners produce the most production among other fishing gears. The results of this productivity calculation will be used later to determine the strength of each fishing gears.

Productivity was the catch of every fishing gear in a given period of time, both in the range of years and months. The productivity calculation was performed when the catch data and the number of units or trips per gear are known [15]. The productivity calculation results from the catch by fishing gear divided by the number of annual fishing gear trips [16].

Fishing gear standardization is needed [5,17]. in tropical countries such as Indonesia due to multi gear and multi species fishing activities. This standardization is applied to make uniform catch ability of variative fishing gear used to exploit fish stock. Several researchers have applied fishing gear standardization in their research about fisheries stock assessment Assessment of multigear type at small-scale fisheries in Sungsang Estuary Banyuasin [18–20]. The calculation of Fishing Power Index (FPI) for fishing gear in the years 2003-2017 shows that the gear used as standard was a high productivity fishing gear (dominant) and FPI value 1. Purse seine was the highest productivity fishing gear with an FPI of 1. It can be concluded that purse seine was a standard fishing gear with a catch ratio that means one gear can produce more fish than another gear to other gear, based on the level of productivity of each fishing gears. The calculated FPI value was then used to calculate the standard effort by multiplying the FPI value of each fishing gears by the number of trips of each fishing gears.

If different types of fishing gears are used in an area, one of these gears can be used as the standard fishing gear. While other fishing gear can be standardized against these gears. Fishing gear which was designated as standard fishing gears has a fishing factor or FPI = 1. The standard effort was calculated by multiplying Fishing Power Index (FPI) values by effort of fishing gear analyzed [21].

The value of utilization status of Indian mackerel (*R. kanagurta*) in Aceh east coast waters was 69%. This means that the utilization status of Indian mackerel (*R. kanagurta*) in Aceh east coast waters has been moderately exploited. Catches of Indian mackerel (*R. kanagurta*) has fluctuated. The variation was caused by the average fishing effort by year, which does not correspond to the optimal fishing effort. Estimates of fishing decreased when effort for catching was close to the maximum effort. Even if the fishing effort exceeds the maximum fishing level of effort, the estimated catch was negative or the fisherman does not received catch.

Indian mackerel was a type of consumer fish for the community. Due to the high demand of consumers in the fish market, fishermen have been fishing on a large scale. Extensive fishing activities could be disrupted the growth cycle of Indian mackerel and reduced the population in the waters. Mortality in detention was influenced by the degree of exploitation [22].

Biomass of Indian mackerel (*R. kanagurta*) tended to show increasing fluctuations between 2003 and 2017. This was due to the ability to grow high resources of Indian mackerel (*R. kanagurta*). The catch of Indian mackerel (*R. kanagurta*) by fishermen was lower than that of fish production or fish growth, so that the production could cover the exploitation rate of fishermen for Indian mackerel (*R. kanagurta*) resources in Aceh east coast waters Province.

The decrease in production may be due to an increase in fishing effort, which was carried out without provision. The high effort on the exploitation of fish stocks in the waters. The amount of sustainable production will continue to increase, along with the increasing efforts to reach the maximum level. However, if the effort exceeds the maximum, sustainable production decreases and the number of efforts increases. In addition, the decline in production also occurs due to

environmental conditions for which there was no suitable water and feed for fisheries resources, so that fish tend to migrate to other areas [23].

Alternative management of fisheries resources must take into account two aspects, namely the state of resources and high production. The increase of biomass stocks was attributable to the fact that the implementation of effort does not exceed the maximum level of effort. Conversely, the decline of biomass stocks was caused by effort that was implemented beyond the maximum level of effort. In addition, the value of catch or growth would decline at a given times. This was influenced by the value of carrying capacity (k) or the maximum capacity of the environment to absorb biomass. It can also be influenced by the high intrinsic growth rate (r) and the availability of biomass food in the environment.

In unused biomass, fish stocks increase to varying degrees depending on their size and reach the maximum weight of natural balance. Abiotic and biotic factors affected the growth of fish stocks are considered constant. Three components of the growth rate of fish stocks, namely rejuvenation (small fish entering the stock), increase in individuals (individual fish ready to grow into large stocks), natural mortality (weight of fish biomass was reduced by natural mortality and predation). Schaefer's model of surplus production assumes that the net increased in biomass depends on the large population [24].

5. Conclusion

Value of MSY, TAC and TAE of Indian mackerel (*R. kanagurta*) in Aceh east coast waters was 14858 ton/year, 11886 ton/year, and 74088 trip/year respectively. While its utilization rate was categorized as moderately exploited. In addition, the sustainable management scenario of the Indian mackerel (*R. kanagurta*) for the next eight years (2018-2025) would lead to the highest biomass stocks in 2025, namely the allocation of total allowable fishing effort (TAE).

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