Productivity of Yellowfin Tuna (Thunnus Albacares) by Using Hand Line in Majene Regency, Indonesia

Muh. Aldhy Hatmar
Fisheries Study Program, Graduate School, Hasanuddin University, Jl. Perintis Kemerdekaan Km.10, Makassar 90245, South Sulawesi, Indonesia Email: alfanelwan@fisheries.unhas.ac.id

Alfa F.P. Nelwan
Faculty of Marine Science and Fisheries, Hasanuddin University. Jl. Perintis Kemerdekaan Km.10, Makassar 90245, South Sulawesi, Indonesia

Musbir
Faculty of Marine Science and Fisheries, Hasanuddin University. Jl. Perintis Kemerdekaan Km.10, Makassar 90245, South Sulawesi, Indonesia

Abstract

Productivity and production factors need to be studied in order to determine the steps that fisherm en could take to increase tuna production volume without causing significant losses. Therefore, this study examines the fishing productivity of tuna handliners and determine the factors with the most influence on their productivity. This research was conducted from August to November 2022 in Rangas Village, Banggae District, Majene Regency, Indonesia using a survey method and a purposive sampling technique. Data were analysed using multiple linear regression of the Cobb-Douglas production function. Fishing productivity was obtained from the ratio of the amount of catchesand duration of fishing time. The results showed that the relationship between fishing productivity with the time fishing is declining withincreasing duration of time fishing. Fishing productivity shows the downward trend. The factors affecting the productivity of the handline tuna fishery comprised vessel capacity (GT), engine power (HP), fuel volume (L), number of crew members (fishermen), and duration of fishing times (minute). The production factors with the greatest influence on the productivity of the handline tuna fishery was duration of fishing times (minute).

Keywords: *Tuna Hand Line, Productivity, Cobb-Douglas Function, Yellowfin Tuna, Production Factors.*

INTRODUCTION

Majene Regency is a tuna landing site in Indonesian Fisheries Management Area (FMA) 713 (Jurwanto, 2021). Majene Regency has access to extensive tuna resources because of its geographical location on the Makassar Strait coast of Sulawesi. The Makassar Strait, most of which is in FMA 713, is a tuna migration route and an important Indonesian tuna fishing ground. Tuna are large pelagic fish and a leading fisheries commodity in Majene Regency, making a significant economic contribution to the fisheries sector. This is especially so in Rangas Village, Banggae District, where local fishermen have been fishing for tuna for a long time. They target large pelagic fish, especially tuna, using tuna handlines and fish attracting devices (FADs) as auxiliary gear. Small-scale fisheries are those carried out by small-scale fishermen (Andrew & Evans, 2009; Lopes & Begossi, 2011 ; Barnes-Mauthe et al., 2013) or traditional fishermen (Al-Marshudi & Kotagama, 2006; Rahim & Hastuti, 2018) that tend to operate in coastal waters (Rahim et al., 2018). The fishers typically work as individuals, with one to two units owned by each vessel owner (Nelwan et al., 2015). They typically use outboard engines to power their fishing vessels (Ele & Nkang, 2014) and simple fishing gear (Retnowati, 2011). The Rangas Village tuna fishery can be classified as small-scale because the fishing vessels used are small (3 to 10 GT), relatively inexpensive and easy to operate, and built with simple designs and construction methods.

Tuna are highly migratory pelagic fish; tuna fisheries are therefore widespread (Maguire et al., 2006). In addition, tuna is a valuable globally-traded commodity with both local and export markets (Kantun et al., 2014). In view of this high economic value, tuna fisheries should be given special consideration in fisheries management, in particular tuna handline fisheries. Drafting appropriate handline fisheries management policy requires information on the performance and capacity of this gear, in particular estimates based on productivity, obtained by comparing production and effort. Fishing effort is typically estimated based on the dimensions of the fishing gear, the vessel used, the number of operational fishing days, and the fishing technology used (Nelwan et al., 2015). Fishing effort is one of the production factors that will determine the catch volume in a given fishing ground or fisheries management area (FMA).

Tuna catches in Majene Regency fluctuated over a five year period prior to 2021 (Jurwanto, 2021). These fluctuations are thought to have been influenced by climatic changes and weather patterns. Factors that can affect catch volume are not limited to climate and weather (Mcowen et al., 2015) but also to changes in fishing effort and production (Eggert &Tveteras, 2001) and can affect the economic welfare of fishing communities (Israel et al., 2006), in particular the income of fishers (Long & Yabe, 2011; Primyastanto, 2015), and outgoings on food and other consumables (Mukarrama et al., 2010; Oladimeji et al., 2015). To mitigate these effects, it is important to have reliable information regarding the effect of production factors on effectiveness and efficiency to optimise fishing effort. Fishing effort can be considered optimal if the catch volume is optimised without damaging or destroying the natural resources on which the fishery depends (Boesono et al., 2011).

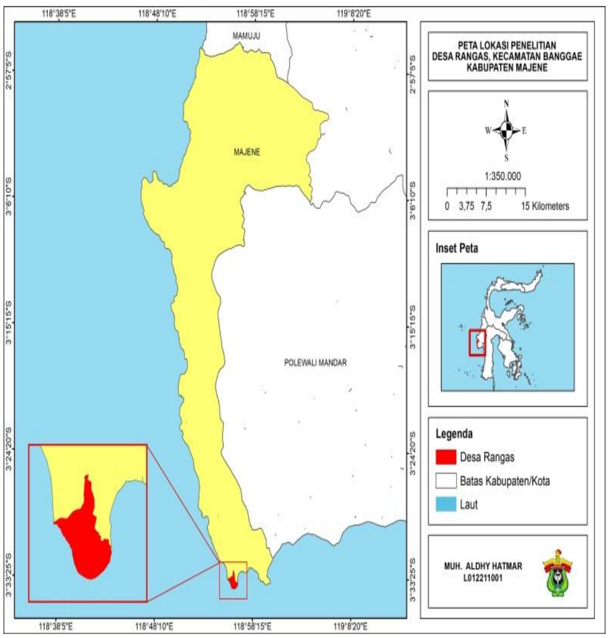
In general, effective and efficient production factors will increase fishing catch volume and fisher income (Alhuda et al., 2016). A technical efficiency approach using the Cobb-Douglass stochastic frontier production volume estimation method can be applied to estimating the efficiency of fishing vessels (Jamnia et al., 2015; Zibaei, 2012; New, 2012). In estimating the technical efficiency of tuna fishing vessels in Santos, Philippines, Alviola et al., (2016) identified key factors affecting catch volume as vessel tonnage (GT), fishing effort (days), as well as fuel and water consumption.This means that, to fish efficiently, fishermen must take into account a combination of production factors as well as catch volume and/or value. Different production inputs will result in different levels of efficiency (Azizah, 2016).

Production factors need to be studied in order to determine the steps that fishermen could take to increase tuna production volume without causing significant losses. However, there is a lack of knowledge regarding the production factors that influence the catch of handline tuna vessels targeting yellowfin tuna (Thunnus albacares) based in Rangas Village, Banggae District, Majene Regency. This study examines the fishing productivity of tuna handline and evaluated several production factors affecting the productivity of tuna handline fishing in order to determine which factors had the greatest influence on the productivity of the tuna handline vessels based in Rangas Village, Banggae District, Majene Regency

Materials and Methods

This research was conducted in Rangas Village, Banggae District, Majene Regency, West Sulawesi Province, Indonesia. The study was conducted over a four month period from August to November 2022.

Figure 1. Map of Majene Regency in West Sulawesi, Indonesia showing the study site.



Data used in this study included primary and secondary data. Primary data were collected in the field through observation and interviews with tuna handline fishers, while secondary data were obtained through a desk study of relevant literature and previous studies. Data were collected on tuna catch volume (in kg), fuel volume (in litres), trip length (days), engine power (HP), vessel tonnage (GT) and the number of crew members (fishers). To collect primary data, this study used a survey method with purposive sampling. Fishing vessels sere selected from the tuna fishing fleet in order to provide suitable data for the purposes of the study, and respondents were selected from the sampled population of fishers based on their capacity to provide the information required for the study. The fishing vessel sample size was based on the Slovin equation (Umar, 2009):

$$n = \frac{N}{1+Ne^2} \text{.................................(1)}$$

$$N = \frac{357}{1+357 \cdot (0.2)^2}$$

$$n = 23.4\ (23)$$

where:

n = sample size

N = total population

e = margin of error

The total population comprised 357 tuna fishing vessels in Banggae District, Majene Regency (Jurwanto, 2021) with a 20% margin of error (e). Therefore, 23 vessels of varying sizes were selected.

Productivity is used to describe output at each unit of input, so higher productivity means that more can be produced. In this research, the input is fishing effort, where fishing time is the measure arrest attempt. Thus the productivity of handline fishing is determined based on comparison between production by the amount of time spent on fishing (minutes). Productivity was calculated by the following formula (Nelwan et al., 2015):

$$\text{Produtivity} = \frac{Production\ (fish)}{duration\ of\ fishing\ times\ (minutes)} \text{.......(2)}$$

Production factor analysis was applied to describe the relationships between the factors affecting production. In reality it is not possible to fully observe the effect of specific production factors on production; therefore is necessary to make a model which simplifies the relationships between production factors and the output (Soekartawi, 2003). The relationship between various production factors and production output can be quantified and calculated using the logarithmic form of the following Cobb-Douglas production function equation (Soekartawi 2003):

$Y = aX_1{}^{b1}X_2{}^{b2} \ldots X_i{}^{bi} \ldots \ldots X_n{}^{bn}e$...(3)

where:

Y = dependent variable

a = constant

X1 to Xn= independent variables (1 to n)

b1 to bn= independent variable exponents

e = margin of error

Applying a logarithmic transformation simplifies equation (3) into a linear format, enabling the use of multiple linear regression. However, before applying multiple regression it is necessary to ensure the data meet the assumptions for multiple regression analysis, in particular the classical multiple co-linearity test (Sarwono, 2013). The data were also tested for normality. In this study, the independent variables were the production factors (X1, X2, X3,X4, X5) and the dependent variable was production (Y), therefore the log-transformed multiple linear regression equation becomes:

$LnY = Lna0 + b1LnX_1 + b2LnX_2 + \cdots + b5\ LnX_5 + Lne$..................................(4)

where:

Y = Production

X1 ...X5 = Production factor 1 to 5

a0 = Intercept

b1 to b5 =Production factor regression coefficients

e = Margin of error

The variables used in this study were:

Y =Yellowfin tuna (Thunnus albacares) catch (kg/4 months of observation);

X1 = Vessel tonnage (GT);

X2 = Engine power (HP);

X3 = Number of crew members (crew)

X4 = Fuel used (L/4 months of observation);

X5 = Efforts/Duration of fishing time (Minutes/4months of observation).

Data analysis was implemented in SPSS version 25. Statistical tests were performed on the Cobb-Douglas production function to evaluate the relationship between the production factors and production as follows:

The capacity of the regression model to predict production was evaluated using the F test with the following decision rules at the 95% confidence level (α = 0.05):

If Fscore< Ftable , reject alternative hypothesis Ha, accept null hypothesis Ho

If Fscore> Ftable, accept alternative hypothesis Ha

where:

Ho: bi = 0 (none of the independent variables Xi has a significant effect on the dependent variable Y)

Ha: bi ≠ 0 (at least one independent variable has a significant effect on the dependent variable Y).

If Ha was accepted, then the coefficient of determination (R2) calculated to estimate the proportion of the variation in production that could be explained by the independent variables selected.

The influence of each technical production factor on production was evaluated using the Student's t-test with the following decision rules at the 95% confidence level (α = 0.05):

If tscore < ttable, reject alternative hypothesis Ha, accept null hypothesis Ho

If tscore> ttable, accept alternative hypothesis Ha

where:

Ho: bi = 0 (the effect of the independent variable X on the dependent variable Y is not significant)

Ha: bi ≠ 0 (the independent variable X has a significant effect on the dependent variable Y)

Results and Discussion

Tuna Handline Fishing Vessels and Gear

The tuna handline vessels based in Rangas Village, Banggae District sampled in this study (Figure 2) had the following dimensions: length overall (LOA) 13 - 22 m; width (beam) 1.59 – 2.44 m and depth (draught + freeboard) 0.75 – 1.2 m. Tonnage ranged from 3 GT to 10 GT, and the vessels were powered by engines of several makes (Jiandong, Domphin and Mitsubishi) rated at 54 - 150 PK. In addition, each vessel carried between 2 and 6 wooden canoes (sampan) used for tuna fishing.

Figure 2. A typical tuna handline fishing vessel in Majene Regency

Fishing Gear

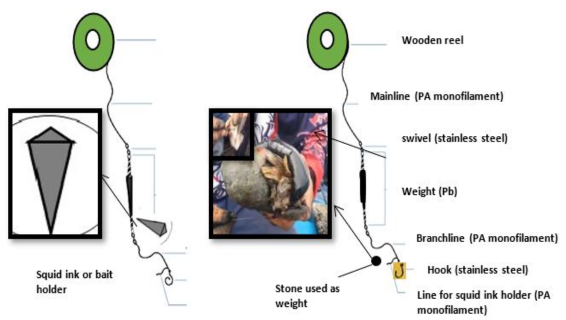
The tuna handline gear used by vessels sampled in this study typically comprised the following parts: a reel, mainline, branchline, weight, hook, and a stone. The specifications are shown in Table 1 and Figure 3.

Table 1. Specification of tuna handline gear in Rangas Village, Majene Regency

No	Component	Material	Size (Number)	Length (m)	Weight (kg)	Number
1	Reel	Wood	-	-	2-3	1
2	Mainline	Monofilament*	300 - 1000	80 - 200	-	1
3	Branchline	Monofilament*	300- 600	20 - 30	-	1
4	Line for squid ink	Monofilament*	150	0.5	-	1
5	Weight	Pb	-	-	1-2	1
6	Hook	Stainless steel	3 – 7	-	-	1
7	Swivel	Stainless steel	-	-	-	2
8	Stone	Stone	-	-	3-4	1

* Polyamide (PA) monofilament fishing line

Figure 3. Typical Tuna Handline Gear



Gear Operating Technique

The tuna longline vessels use fish aggregating devices (FADs) and remain at sea for 3-6 days per trip. These vessels operate with 2- 7 crew, with one fishing master, one engineer and 2 – 5 fishers. On arrival at the fishing ground, the fishers start by catching fish for bait. These can include frigate tuna (Auxis thazard), skipjack tuna (Katsuwonus pelamis), small tuna species(Thunnus sp.) and flying fish (Exocotidae), as well as squid (Loligo sp.).

The handlines used to catch skipjack tuna (Katsuwonus pelamis) and frigate tuna (Auxis thazard) typically have 20 hooks (size 11 – 15). Squid (Loligo sp.) are caught with squid jigs.

The fishers use both live and dead bait. Skipjack tuna, frigate tuna and scads are often used as live bait for catching yellowfin tuna at depths deeper than 80 m. The baitfish are hooked through the upper dorsal region of the body so that they remain in a position which makes them appear to be moving naturally; this hook position also allows the baitfish to remain alive for a relatively long time, so that they have a good chance of being seen and attacked by the target fish. The fishers also employ the following techniques using dead bait when fishing around the FADS (Figure 3). Once a fish has taken the hook, the line is then hauled to the surface with great care until the target fish is close to the boat. The fisher will then hit the fish on the head with a piece of wood, and use a billhook to haul the fish onboard. The main target fish is yellowfin tuna (Thunus albacares).

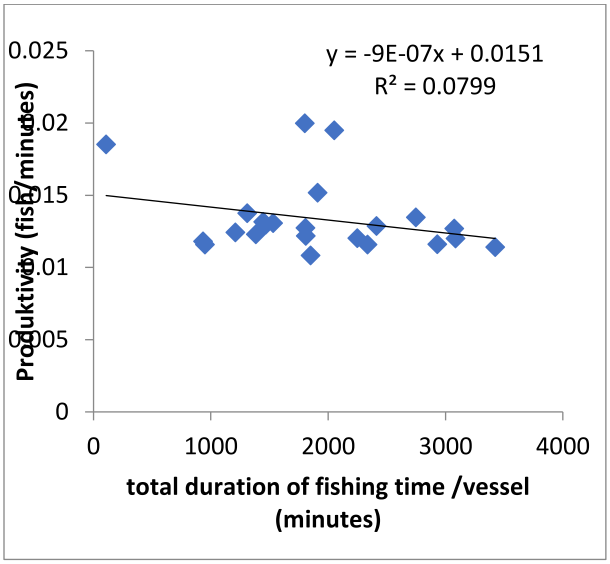
Productivity

The production of tuna data collected over four months (August – November) from the tuna handline fishery in Banggae District, Majene Regency are shown in Table 2. The highest production occurred at fishing vessel 10 was 39 fish (1454.5 kg) and the lowest production occurred at fishing vessel 23 was 3 fish (133 kg).

Table 2. The production of tuna data collected from the tuna handline fishery in Banggae District, Majene Regency

Vessel	Total Effort/Duration of time fishing (minutes)	Production tuna		Average Weight (kg)	Average Fork Length (Cm)
	Positive catch	Kg	Fish		
1	2747	858	37	23.19	106.27
2	1310	439.5	18	31.39	111.36
3	1911	723.5	29	24.95	109.74
4	1468	622.2	19	32.75	121.39
5	2931	962.2	34	31.04	111.51
6	3423	1031.5	39	26.45	109.50
7	3085	1290	37	34.86	119.14
8	2334	760	27	29.23	115.35
9	1807	519	23	22.57	105.13
10	3075	1454.5	39	38.28	123.33
11	1208	462.2	15	30.81	117.43
12	933	393	11	35.73	120.45
13	1807.7	853.5	22	38.80	124.23
14	950	393	11	35.73	119.55
15	1383	598.7	17	35.22	119.35
16	1849	634.5	20	31.73	118.68
17	2411	794.5	31	25.63	107.92
18	2248	867	27	32.11	117.57
19	1446	628.6	19	33.08	118.13
20	1531	638.5	20	31.93	119.65
21	2052	742.5	40	18.56	97.65
22	1802	656.2	36	18.23	98.14
23	244	133	3	44.33	132.83

Figure 4.Trends in the relationship between productivity of tuna and fishing time (Minutes)



The productivity trend of fishing for tuna with handline shows a decreasing trend with the duration of fishing time. The rate of decline in tuna fishing productivity was 9E-07 fish/minute for each additional unit of fishing time (minutes). The coefficient of determination on the trend of the relationship between fishing productivity and fishing time is 0.079 or fishing time explains a change in fishing productivity of 8% (Figure 4). The highest productivity of tuna fishing was 0.02 kg/minute with a fishing time of 1802 minutes, while the lowest productivity of tuna was 0.0108 kg/minute with a fishing time of 1849 minutes.The productivity of handlines operated by fishermen shows a tendency to decrease with increasing fishing time based on the type of fish produced catch (Figure 4). Fishing operations for handline fishing are carried out by fishermen starting before sunrise until 18.00. The trend of decreasing tuna fishing productivity in the location of FADs which is the area fishing can be affected by various factors in particular related to interest in FADs. Interest to FADs is caused by food availability and habitat suitability (Dagorn et al., 2000).

Figure 5. The position of FADs which is a Tuna fishing area used by handline

The fishing ground for handline tuna during data collection was at the geographic position of 03°50' - 04° 15.557' South Latitude and 117° 15' - 119°32.311' East Longitude. Tuna hand line fishing activities were carried out by 23 ships and all fishing take place in FADs. The number of FADs was 73 units.

Tuna Handline Production Factors

The production factors data collected over four months from the tuna handline fishery in Banggae District, Majene Regency are shown in Table 2. The 3–10 GT fishing vessels powered by 24-150 HP engines used 450-1600 L fuel, with 3-7 crew members. The total length of fishing times (efforts) of 244-3423 minute resulted in yellowfin tuna production volumes of 133 - 1454.5 kg.

Table 3. Production factors (X1-X5) and production (Y) for 23 Tuna handlinevessels over the four month study period

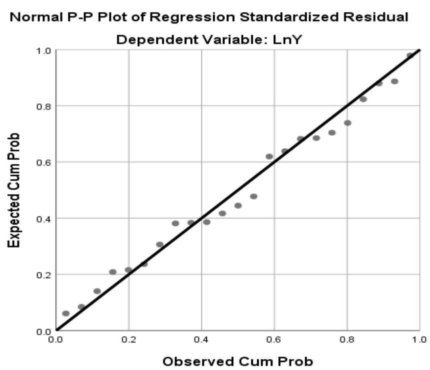
No	Tonnage GT (X1)	Engine Power (HP) (X2)	Crew (X3)	Fuel (L) (X4)	Efforts (Minute) (X5)	Tuna Production (kg) (Y)
1	4	55	5	1600	2747	858
2	5	55	5	600	1310	439.5
3	8	90	6	1400	1911	723.5
4	6	60	5	900	1468	622.2
5	3	54	6	1360	2931	962.2
6	5	63	6	900	3423	1031.5
7	6	59	7	980	3085	1290
8	6	90	5	750	2334	760
9	8	134	5	840	1807	519
10	10	150	7	960	3075	1454.5
11	9	60	6	800	1208	462.2
12	7	60	6	450	933	393
13	10	150	7	930	1808	853.5
14	9	78	6	500	950	393
15	5	54	4	760	1383	580.7
16	9	120	7	1200	1849	634.5
17	3	55	5	1400	2411	794.5
18	4	59	6	1050	2248	867
19	4	60	6	1260	1446	628.6
20	7	90	5	1500	1531	638.5
21	5	60	4	1250	2052	742.5
22	7	90	5	1250	1802	656.2
23	4	24	3	900	244	133

Production Factor Analysis

The tolerance values calculated for the independent variables were all greater than 0.10. The variance inflation factor (VIF) values calculated for the independent variables were all less than 10 (Table 4). It could therefore be concluded that there was no multiple co-linearity between the independent variables used in the multiple regression model. The normality test used a graphical method, observing the distribution of the data around the diagonal line on a normal standardized regression residual P-P plot (Figure 6A). The data were spread along the diagonal, indicating that the data met this criterion for multiple linear regression. The heteroskedasticity test checks for unequal variance in residuals between observations. Heteroskedasticity should not occur in a good regression model. The presences/absence of heteroskedasticity can be seen from the distribution of the data which should be evenly spread with no discernible pattern. The Standardized Predicted Regression Value plot (Figure 6B) shows well dispersed points, indicating that the data meet the multiple linear regression model assumption regarding absence of heteroskedasticity.

To test for autocorrelation, a run test was used. The run test asymptotic sig (2-tailed) value was 0.662 > 0.05 indicating that there was no autocorrelation (Table 4). Based on the results shown in Table 3, the adjusted R2 value was 0.922, indicating that, collectively, the independent variables can explain 92.2% of the variation in the dependent variable, while 7.8% could be explained by other variables not included in the model used in this study.

Figure 6. Results of the normality (A) and heteroscedasticity (B) tests



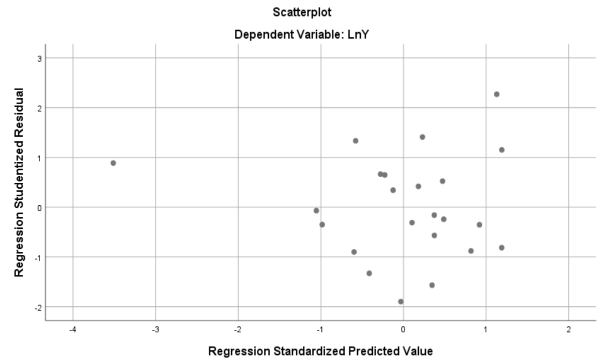


Table 4. Multiple linear regression analysis of tuna handline fishery production factors in Banggae District, Majene Regency implemented in SPSS version 25.

Independent Variable	Unstandardized Coefficients (B)	Sig. (α)	t-test	Collinearity Statistics	
				Tolerance	VIF
X1 Vessel tonnage(GT)	.129	.453	.768	.217	4.604
X2 Engine power (PK)	-.097	.543	-.620	.201	4.964
X3 Number of crew	.278	.202	1.326	.451	2.215
X4 BBM (L)	.113	.295	1.080	.667	1.500
X5 efforts (minute)	.788	.000	8.567	.318	3.145
F_{score}	52.767	.000			
Adjusted R^2	.922				
(Run test) *Asymptotic Sig* (*2-Tailed*)	.662				
n	23				

*Positive ttable = 2.074, Negative ttable = -2.074, Ftable = 2.81

The F-test results (Table 4) show that the value of Fscore at the 95% confidence level (α = 0.05) was greater than Ftable; therefore, Ho is rejected, meaning that, collectively, the independent variables have an effect on tuna production. The t-test results for each of the five production factors gave the following results:

X1, Vessel tonnage (GT): tscore< ttable and sig. > 0.05 so Ho is accepted, indicating that the size of the fishing vessel does not have a significant effect on tuna production.

X2, Engine power (HP): tscore< ttable and sig. > 0.05 so Ho is accepted, indicating that the engine power of the fishing vessel does not have a significant effect on tuna production.

X3, number of crew members: tscore< ttable and sig > 0.05, so Ho is accepted, indicating that the number of crew manning the fishing vessel does not have a significant effect on tuna production.

X4, Fuel : tscore< ttable and sig. > 0.05 so Ho is accepted, meaning that the amount of fuel used does not have a significant effect on tuna production.

X5, Duration of time fishing(Minute): tscore> ttable and sig < 0.05, o Ho is rejected and Ha accepted, meaning that the Duration of time fishing(minute) has a significant effect on tuna production.

Based on the results of the multiple linear regression and statistical tests (Table 4), the Cobb-Douglas production function formula for the tuna handline fishing vessels based in Rangas Village, Banggae District, Majene Regency can be expressed as:

$$\text{Ln } Y = -0.452 + 0.788 \ln X5 \quad ....(5)$$

where:

Y = yellowfin tuna production (kg)

X5 = Duration of Fishing Times (minute)

The results of the t-test show that the ship size/Vessel tonnage (X1), engine power (X2), The number of crew members (X4) and the fuel/L (X4) partially did not have significant effects on the tuna handline production. While the duration of fishing times/efforts variables (X5) has a significant effect on the tuna handline production. The fuel amount variable (X4) has no significant effect on tuna production. A study by Fadhilah et al., (2019) also found that fuel has no significant effect on fishing production of skipjack tuna at Sibolga Nusantara Fisheries Port. Different result of study by Sangadji et al., (2013) in Ambon found that fuel was a production factor with a significant effect on tuna fisheries production, as did a study on tuna handliners operating out of the Bitung Deep Sea Fishing Port by Pontoh et al., (2019). As the fishing vessels are typically quite small and the fishing grounds (FADs) are generally quite nearby in or close to the Makassar Strait, the fishers often return with quite a lot of fuel onboard. This negatively affects the load (catch) that can be carried. Fuel could be reduced, resulting in more efficient payloads.

In this study, the vessel size and capacity did not directly have a significant influence on tuna handline production. Pontoh et al., (2019) found that vessel size (tonnage) gad a significant influence on the engine size and power rating, ship stability, and the capacity for storage in the hold. Larger vessels could store more fish onboard, but their catch depended on the productivity of the gear used and the condition of the target stock. Efendi (2007) considered that there was no guarantee that increasing vessel size would result in increased catch volume. In theory, larger vessels can go further afield and reach more distant and varied fishing grounds. However, if there is a decline in the abundance of the fish stocks, then increasing vessel size is unlikely to improve efficiency.

Larger vessels in general also have larger engines, although this is not always the case. In this study engine power (in HP) did not have a significant effect on tuna handline production. One reason for this result is that in tuna handline fishing the engine is switched off once the fishing vessel has reached the fishing ground, as described by Pontoh et al., (2019). Thetuna handliners sampled in this study launched the canoes carried onboard so that each fisher could use one for fishing around the FAD.

The number of crew members did not have any significant effect on tuna handline production. In general, the Rangas Village vessels only carried a small number of fishers or workers, and their number did not affect the catch. Pontoh et al., (2019) found that increasing this production factors could actually be counter-productive and reduce total production. Nonetheless, the combination of vessel tonnage, engine power and crew size should be optimised, and if appropriate reduced, to achieve production efficiency.

The production function equation obtained indicates that tuna catch is influenced to a significant degree by the one production factors in the equation. The following assumptions can be made based on the Cobb-Douglas production function resulting from the multiple regression model: Duration of fishing times factor had a coefficient (0,788) with an elasticity value < 1, meaning that increasing fishing times duration (minute) tends to decrease tuna production (Decreasing return to scale). Productivity catch that tends to decrease with increasing fishing time (Nelwan et al., 2015). The decrease in fishing productivity along with duration of time fishingis related to stomach condition. Eating behavior will be determined on hunger, satiety or between state of both conditions (Dagorn et al., 2000; Ménard et al., 2007)

Conclusion

Fishing productivity shows the downward trend. The relationship between fishing productivity with the time fishing is declining withincreasing duration of time fishing. The factors influencing the productivity of tuna handlinersbased in Rangas Village, Banggae District, Majene Regency comprised vessel tonnage (GT), engine power (HP), fuel volume, number of crew members, and duration of time fishing(minute). The production factors with the greatest effect on tuna handliner productivity was the duration of fishing time.

Acknowledgements

The authors gratefully acknowledge funding from the Indonesian Government under the 2022 LPDP scheme. The authors also wish to thank the West Sulawesi Provincial Marine and Fisheries Service, the Majene Regency Marine and Fisheries Service, the West Sulawesi tuna traders and tuna handline fishers, and all who provided assistance during this study.

Reference

Al-Marshudi, A.S. & Kotagama, H. (2006). Socio-Economic Structure and Performance of Traditional Fishermen in the Sultanate of Oman. Journal of Marine Resource Economics, 21, 221–230.

Alhuda, S., Anna, Z., & Rustikawati, I. (2016). Analisis produktivitas dan kinerja usaha nelayan purse seine di Pelabuhan Perikanan Pantai Lempasing , Bandar Lampung. Jurnal Perikanan Kelautan, VII(1), 30–40.

Alviola PA IV, Sarmiento, JMP, Digal, L. N, & Comidoy, S. (2016). Factors Affecting the Efficiency of Tuna Fishing Vessels : Implications on Tuna Production Factors Affecting the Efficiency of Tuna Fishing Vessels : Implications on Tuna Production. Elsevier Editorial Sstem for Ocean & Coastal Management, 1–28.

Andrew, N. L., & Evans, L. (2009). Approaches and Frameworks for Management and Research in Small-scale Fisheries in the Developing World. (The WorldFish Center Working Paper 1914).

Azizah U.A. (2016). Efisiensi Teknis dan Ekonomis Unit Penangkapan Jaring Setet Dan Strategi Pengembangannya Di Muncar, Banyuwangi. Institut Pertanian Bogor.

Barnes-Mauthe, M., Oleson, K.L.L., & Zafindrasilivonona, B. (2013). The Total Economic Value of Small-Scale Fisheries with a Characterization of Post- Landing Trends: an Application in Madagascar with Global Relevance. Journal of Fisheries Research, 147, 175–185.

Boesono H., Anggoro S., & B. A. N. (2011). Laju tangkap dan analisis usaha penangkapan lobster (Panulirus sp.) dengan jaring lobster (gillnet monofilament) di Perairan Kabupaten Kebumen. Jurnal Saintek Perikanan, 1(7), 77–87.

Dagorn L, Erwan J, Pascal B, & A. B. (2000). Modelling Tuna Behavior Near Floating Objects From Individuals to Aggregations. Aquatic Living Resources, 13, 203–2011.

Efendi D.S. (2007). Analisis Kapasitas Berlebih Perikanan Pukat Cincin Pekalongan Dalam Kerangka Kebijakan Perikanan Tangkap Di Laut Jawa dan Sekitarnya. Institut Pertanian Bogor.

Eggert, H., & Tveteras, R. (2001). Stochastic Production and Heterogeneous Risk Preferences: Commercial Fishers' Gear Choices. (No. 54; Working Papers in Economics September 2001.).

Ele, I.E., & Nkang, M. O. (2014). Analysis of Production Determinants and Technical Efficiency In Crayfish Production in The Lower Cross River Basin.Nigeria. Journal of Research In Humanities and Social Science, 2(11), 30–36.

Fadhilah A, Pulungan A, Soemaryono Y, Y. E. & D. A. (2019). CPUE analysis of skipjack tuna (Katsuwonus pelamis) at the Sibolga Nusantara Fishery Port. IOP Conf. Series: Earth and Environmental Science, 260 012112. https://doi.org/doi:10.1088/1755-1315/260/1/012112

Israel, D.C., Adan, E.Y., Lopez, N.F., & Castro, J.C. (2004). Perceptions of Fishermen Households on the Long-Term Impact of Coastal Resources Management in Panguil Bay Philippine. Journal of Development, 31(1), 107–134.

Jamnia, A.K., S.M. Mazloumzadeh, & A. K. (2015). Estimate the Technical Efficiency of Fishing Vessels Operating in Chabahar region, Southern Iran. Journal of the Saudi Society of Agricultural Sciences, 14(1), 26–32.

Jurwanto, W. (2021). Produksi Tuna Di Provinsi Sulawesi Barat. Webinar #1 Potensi Tuna Sulawesi Barat.

Kantun W, Mallawa A, & R. N. (2014). Struktur Ukuran dan Jumlah Tangkapan Tuna Mandidihang (Thunnus Albacores) Menurut Waktu Penangkapan dan Kedalaman di Perairan Majene Selat Makassar. Jurnal Saintek Perikanan, 9(2), 39–48.

Long, L.H., & Yabe., M. (2011). Factors Affecting to Household Income of The Kinh and The Ethnic Minority in Rural Vietnam: A Case Study in The Buffer Zone of Bach Ma National Park. Asian-African Journal of Economics and Econometrics, 1(11), 135–145.

Lopes, P.F.M., & Begossi, A. (2011). Decision-Making Processes By Small-Scale Fishermen on the Southeast Coast of Brazil. Journal Fisheries Management and Ecology, 2(3), 1–11.

Maguire, J.J., Sissenwine, M., Csirke, J., Grainger, R. & Garcia, S. (2006). The state of world highly migratory, straddling and other high seas fishery resources and associated species. (FAO Fisheries Technical Paper. No. 495.).

Mcowen, C.J., Cheung, W.W.L., Rykaczewski, R.R., Watson, R. A., & Wood, L. J. (2015). Is fisheries production within Large Marine Ecosystems determined by bottom-up or top-down forcing? Fish and Fisheries, 16(4), 623–632. https://doi.org/https://doi.org/10.1111/faf.12082

Ménard Frédéric, Anne Lorrain, M. P. &, & Marsac, F. (2007). Isotopic evidence of distinct feeding ecologies and movement patterns in two migratory predators (yellowfin tuna and swordfish) of the Western Indian Ocean. Mar Biol., 153, 141–152.

Mukarrama, M.M.F., Udugama, J.M.M., Jayasinghemudaligae U.K., I., S.M.M., & Dissanayake, S. N. (2010). Assessing the Household Food Security of Marine Fisheries Sector in Sri Lanka: Case of Muslim Fishing Community in the Beruwala Divisional Secretariat Division. Journal Aquatic Science, 61–73.

Nelwan, F.P.A., Sudirman, Zainuddin M, & Kurnia M. (2015). Produktivitas Penangkapan Ikan Pelagis Besar Menggunakan Pancing Ulur Yang Berpangkalan di Kabupaten Majene. Jurnal Marine Fisheries, 6(2), 129–142.

New, R. (2012). Management changes and vessel;level technical efficiency in the Eastern Tuna and Billfish Fishery: a stochastic frontier analysis. 2012 Conference (56th), February 7-10, 2012, Fremantle, Australia 124349, Australian Agricultural and Resource Economics Society. https://doi.org/DOI: 10.22004/ag.econ.124349

Oladimeji, Y., Abdulsalam, Z., Damisa, M. & Omokore, D. (2015). Analysis of Food Consumption Pattern among Rural Fishery Households: A Panacea to Poverty Alleviation in North Central Nigeria. Asian Journal of Agricultural Extension, Economics & Sociology, 6(2), 102–110.

Pontoh. P. &Luasunaung. A, R. E. (2019). Analysis of production factors that affect the productivity of tuna handliners based in Bitung Oceanic Fishing Port. Journal of Aquatic Science & Management, 7(1), 7–12.

Primyastanto, M. (2015). Economic Analysis of Pandega Fishermen Household at Madura Strait to Keep Food Security. International Journal of Oceans and Oceanography, 9(2), 97–104.

Rahim, A., & Hastuti, D. R. D. (2018). Applied Multiple Regression Method with Exponential Functions: an Estimation of Traditional Catch Fishermen Household Income. Journal of Physics : Conference Series, 1028(1), 1–8.

Rahim, A., Hastuti, D.R.D. & B. N. (2018). stimation of HouseholdConsumption Expenditure of Small-Scale Fishermen in Indonesia. Russian Journal of Agricultural and Socio-Economics Sciences, 11(83), 375–383.

Retnowati, E. (2011). Nelayan Indonesia Dalam Pusaran Kemiskinan Struktural (Perspektif Sosial, Ekonomi, dan Hukum). Jurnal Perspektif, XVI(3), 49–159.

Sangadji S.,& Mustaruddin, W. H. (2013). Pengaruh Faktor Produksi Terhadap Pengembangan Perikanan Tuna Di Kota Ambon. Jurnal Teknologi Perikanan Dan Kelautan, 4(1), 1–8.

Sarwono. (2013). Jurus Ampuh SPSS untuk Riset Skripsi. Elexmedia Komputindo Kompas Gramedia.

Soekartawi. (2003). Teori Ekonomi Produksi Dengan Pokok Bahasan Analisis Fungsi Cobb-Douglass. PT. Raja Grafindo Persada.

Umar, H. (2009). Metode Penelitian Untuk Skripsi dan Tesis Bisnis. Penerbit PT Raja Grafindo Persada.

Zibaei, M. (2012). Technical Efficiency Analysis of Fisheries: Towards an Optimal Fleet Capacity. Sustainable Agriculture Research, 1(1), 96–102.