Model of skipjack (*Katsuwonus pelamis*) production based on social and economic aspects in the Buhung Pitue Island, Indonesia

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Abstract. One of the fisheries resources with big potential and high economic value is skipjack tuna (*Katsuwonus pelamis*). Skipjack tuna is a valuable commercial fish, sold fresh, frozen, or processed as canned fish, dried fish, or smoked fish. The study aims to analyze a model of increasing the production of skipjack with employing variables of social and economic aspects on Buhung Pitue Island. The analytical method used in this research was the inferential statistical analysis using the SEM (Structural Equation Modeling) approach. Respondents were 270 fishermen who caught skipjack tuna on Buhung Pitue Island, Indonesia. The results showed that the average profit of fishermen in the peak season was IDR 41,812,500, while the regular season was IDR 23,062,500. Meanwhile, the average of fishing trip was at around 16 days to 20 days per trip. The results of the hypothesis analysis show that there are two unproven hypotheses, namely the H_2 hypothesis (the mediating variable did not significantly influence the increase of skipjack tuna fishing production in the Buhung Pitoe Island), and hypothesis H_6 regarding social factor variables. Futhermore, a model of the relationship between fisherman characteristics and catch output through economic considerations could be inferred for enhancing skipjack tuna production in the Buhung Pitoe Island.

Key Words: fish production, *Katsuwonus pelamis*, SEM model, sustainable.

Introduction. The fisheries sector has become a global issue as the world economy paradigm changes, from a terrestrial economy to a maritime economy (De Silva 2000). The availability of resources on land such as forests (Isbell et al 1996), mining materials (Calvo et al 2016), mineral materials (Wagner & Light 2002) and productive agricultural land is running low (Van Straaten 2006). On the other hand, world population growth continues every year in all of countries (He et al 2016; Passel & D'Vera Cohn 2008). The lack of jobs and food for the world population creates a continuous pressure for the fishing industry to become a new economic growth engine for the world (Barton & Fløysand 2010; Lembo et al 2018). The high demand for seafood has made the ocean to be a destination for large-scale economic activities (Fabinyi et al 2012). Capture fisheries development on a large scale is conducted for meeting the world food consumption (Washington 2008). High and unlimited exploitation, as well as the use of fishing gear that is not environmentally friendly, leads to high pressure on resources and ecosystems (Garcia & Rosenberg 2010). This condition is the main cause of resource degradation.

The decline in the world's fish catch is the impact of the decline in fish stocks, as well as various other factors, both internal factors such as fishermen characteristics, capital (Singh et al 2006), and external factors such as climate change (Barange et al 2014; Sumaila et al 2011), policies (Mous et al 2005) etc. A decrease in fish catch can have various impacts, including the emergence of conflicts between fishermen and even conflicts with policy makers. According to Daris et al (2019) and Daris et al (2020), one of the conflicts that often occurs in the fisheries sector is vertical conflict between fishermen and a horizontal conflict with policy makers. It is further stated that the conflict arises because of different interests in the management of fishery resources.

The skipjack tuna (*Katsuwonus pelamis*) is one of the fishery resources with a high market and and economic worth. Economically, they have a high commercial value, and is sold fresh, frozen, or processed as canned fish, dried fish, or smoked fish (Steven et al 2017). Moreover, in the environment, those animals travel large distances and live in tropical and subtropical waters (Mugo et al 2010; Surman et al 2018). Their distribution generally follows a convergence line flow circulation between cold and hot currents which are areas with high food availability (Loukos et al 2003). Its distribution area stretches around 400 north latitude to 300 south latitude, while the largest fishing area is along the equator, 100 north latitude to 100 south latitude (Lehodey et al 1997). Therefore, in Indonesia's ocean, skipjack are often found around Kalimantan, Sulawesi, Halmahera, Maluku Islands and Irian Jaya (Satria & Kurnia 2018).

Catching skipjack tuna in Indonesia is generally carried out using pole and line (huhate), and some fishermen use trolling lines, purse seines, gill nets, and seine net (Martasuganda & Wahju 2011; Nurdin & Nugraha 2017; Toatubun et al 2016). As a result, the pole and line are still the most effective and selective fishing tools to catch skipjack tuna (Litaay et al 2020). Regarding to kind of fishing gear, the fishermen in Buhung Pitue Island prefers using pole and line for catching tuna as well.

In order to know the production level of skipjack tuna catches on Buhung Pitue Island, it was important to conduct a research on a model of the production of skipjack tuna that considers social and economic aspects on Buhung Pitue Island, which was the purpose of this study.

Material and Method

Time and place. This study was conducted in November 2019 in Buhung Pitoe island, Sinjai district, South Sulawesi, Indonesia and involved over 200 fishermen. The collection data on this research was the correlation among fishermen character, economy factor, social factor, and catching production (Table 1).

Types and sources of data. The type of data used in this study was primary data obtained from interviews and questionnaires by engaging 270 respondents amongst the fishermen in Buhung Pitoe Island. All respondents are people that catch *K. pelamis.* Moreover, the questions were created based on various factor that are presented in Table 1.

Table 1

Research variables and indicators

Variable	*Indicator*	*Symbol*
Fisherman character (X_1)	Age	X1.1
	Education	X1.2
	Experience	X1.3
	Total liabilities	X1.4
Economy factor (X_2)	Market	X2.1

	Fish price	X2.2
	Financial capital	X2.3
Social factor (X_3)	Credibility	X3.1
	Integrity	X3.2
	Culture	X3.3
Catching production (Y)	Season	Y1
	Fishing ground	Y2
	Catching unit	Y3
	Trip	Y4

Data analysis. The present study used inferential statistical analysis with the SEM (Structural Equation Modeling) method approach which is a statistical technique used to build and test statistical models (Sarstedt et al 2017; Wong 2013). According to Abdillah and Hartono (2015), SEM is a multivariate analysis technique that allows researchers to examine the relationship between complex variables both recursive and non-recursive to obtain a comprehensive picture of the model. There is an advantage of SEM that it can test all variables simultaneously in the model (Sarwono & Narimawati 2015). It has 2 different models, a) measurement model and b) structural model. The measurement model describes the relationship between indicators and constructs (latent variables). Meanwhile, a structural model describes the relationship between constructs (latent/unobserved variables or variables that are not measured directly), which generally consists of independent and dependent variables.

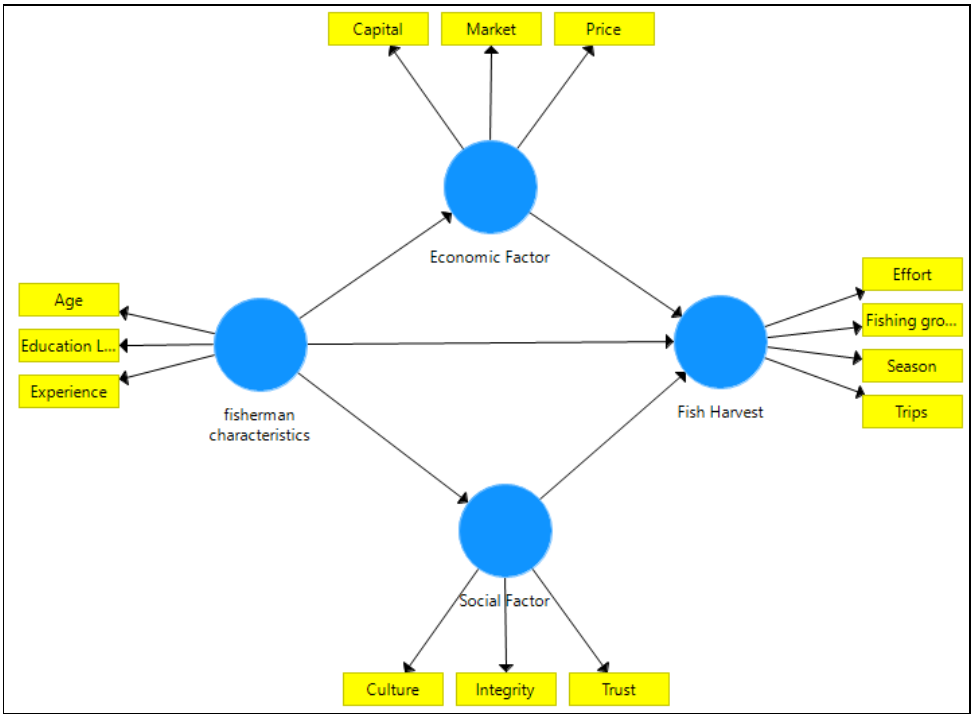

Figure 1. Structure model.

The independent variables in this study included: fisherman characteristics (x1), economic factors (x2), and social factors (x3), while the dependent variable were the catch production (y). Graphically, the structural model developed in this study is described as follows in Figure 1.

Figure 1 shows the relationship among variables and it would be the research hypothesis.

- The first hypothesis: there was a significant relationship between fishermen characteristics and catch production.
- The second hypothesis: there was a significant relationship between fishermen characteristics and catch production through economic and social factors.
- The third hypothesis: there was a significant relationship between fishermen characteristics and economic factors.
- The fourth hypothesis: there was a significant relationship between fishermen characteristics and social factors.
- The fifth hypothesis: there was a significant relationship between economic factors and catch production.
- The sixth hypothesis: there was a significant relationship between social factors and catch production.

Results and Discussion

Tuna catching business. The survey results showed that fishermen on Buhung Pitoe Island did skipjack fishing activities in Flores, Bali and Lombok waters. Furthermore, the farthest fishing ground location is Bali waters, which could reach 700 km to 800 km or around 490 miles to 500 miles to the sea. Meanwhile, the closest location is the Flores Sea, which is about 250 km to 300 km or about 150 miles to 200 miles to the sea. The average travel time from fishing base to fishing ground was 48 h, and the shortest time was 24 h. In general, the average trip time was around 16 days to 20 days. Moreover, the average fishing cost was IDR 12,175,000 for each unit of the vessel in one fishing operation. In detail, the amount of operational costs that was used routinely in each skipjack fishing operation are shown in Table 2:

Table 2

Operating costs of skipjack fishing business on Buhung Pitoe Island

No	*Operasional cost*	*Total cost (IDR)*	*Percentage (%)*
1	Oil cost	5,875,000	48.25%
2	Cost of supplies	4,000,000	32.85%
3	Ice block cost	2,300,000	18.89%
	Total	12,175,000	100.00%

Based on the data in Table 2, it reveals that the largest cost in fishing operations for skipjack tuna was the cost of fuel, which reached 48.25 % or an average of 5.87 million IDR per trip. Meanwhile, the cost of supplies and ice block followed for second and third position, respectively, accounting for 32.85 % and 18.89 % of total cost production, respectively. However, in actuality, the long journey duration was equivalent to the amount of fish caught. The catch of skipjack tuna as well as other pelagic fish, it is divided into two fishing seasons, such as the wet season (September to December), and the dry season in May to August each year (Table 3).

Table 3 represents the cathing production, fish price, and income in the wet and dry season. Overall, in the wet season, fishermen could obtain the higher yield, including catching production and income than in the dry season. The results found that the total income during the wet season reached IDR 41,812,500, which was almost 2 times higher than the low season, accounting for IDR 23,062,500. The wet season income was classified as relatively profitable, which the operating cost per trip was around IDR 12,175,000. It means that during the peak season, fishermen got a profit of IDR 29,637,500 per trip, while the low season obtained a profit of IDR 10,887,500 per trip.

Table 3

Fish catch on Buhung Pitoe Island

No	*Result*	*wet season (month 9 to 12)*	*dry season (month 5 to 8)*
1	Catching production (kg)	2,788	1,538
2	Fish price (IDR)	15,000	15,000
3	Income (IDR)	41,812,500	23,062,500

Structural equation modeling. SEM-PLS (Structural Equation Modeling-Partial Least Squares) was used to test the model in this study. According to Hair Jr et al (2016) and Hair Jr et al (2017), the SEM-PLS method can provide a systematic evaluation of the model being studied. Systematically, several things are produced or tested from the model, such as a) Evaluation of the Measurement Model (Outer Model), b) Evaluation of the Structural Model (Inner Model), c) analysis of mediating variables and d) hypothesis testing.

The results of the outer model show that all indicators used in the model significantly reflected the construct variables with an outer loading value > 0.7. According to Ghozali (2015), the individual reflective size is high or significant, if it has an outer loading value more than 0.7.

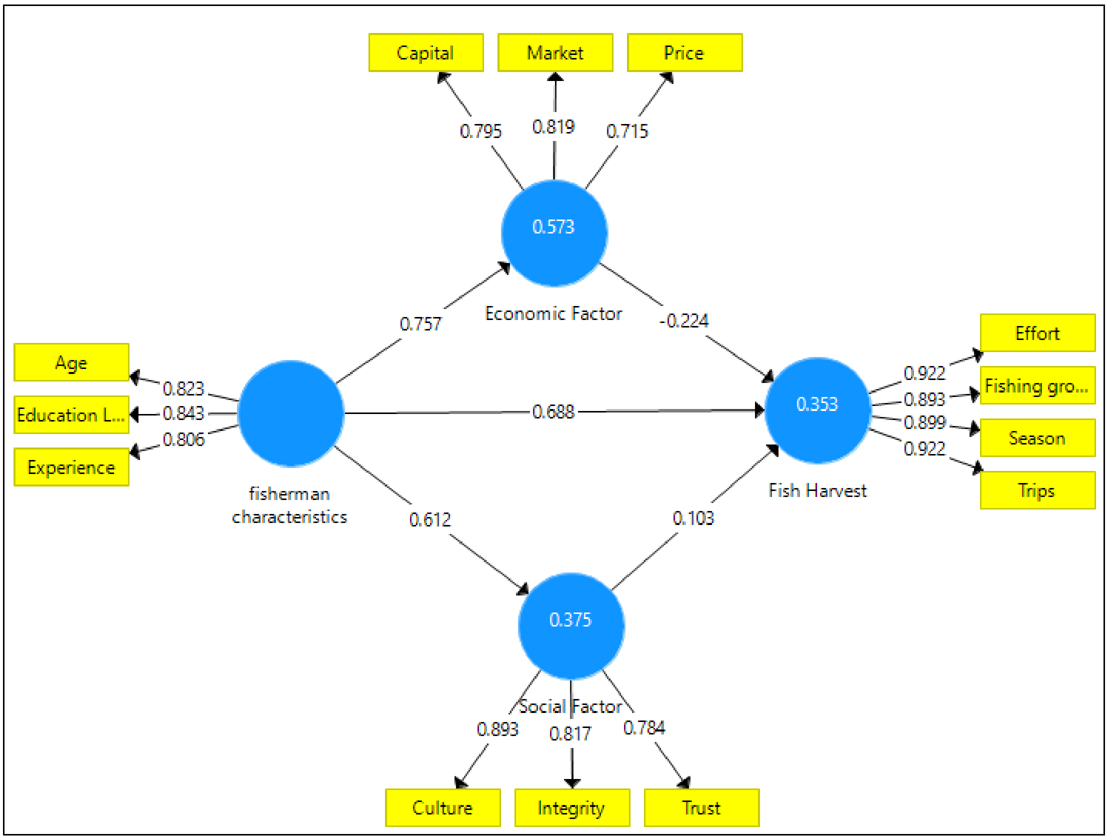

Figure 2. PLS algorithm model.

Figure 2 reveals that all indicators have an outer loading value above 0.7 so that it could be accepted and used in the model. Thus, the model could be continued to evaluate the structural model. According to Gefen et al (2000), the structural model is a model to describe the relationship (correlation) between the construct variables (latent variables). The main evaluation in testing the structural model is the evaluation of the T-statistic value, which is a value to describe the significance of the model. The T-Statistical evaluation was carried out with a confidence level of 95% with the two-way method. The t-test (t-statistic) value must be more than 1.96 based on the value in the T-table or the p-value value to be considered significant. The statistic evaluations are presented in Table 4.

Table 4

T-Statistical Value

	Code	*Original Sample (O)*	*Sample Mean (M)*	*Standard Deviation (STDEV)*	*T Statistics (|O/STDEV|)*	*P Values*
Economy factor > Catch production	R1	-0.224	-0.230	0.097	2.295	0.022
Social Factors > Catch Production	R2	0.103	0.112	0.084	1.227	0.220
Characteristics of Fishermen > Economic Factors	R3	0.757	0.756	0.035	21.366	0.000
Characteristics of Fishermen > Social Factors	R4	0.612	0.608	0.061	9.960	0.000
Characteristics of Fishermen -> Catch Production	R5	0.688	0.690	0.080	8.621	0.000

Table 4 reveals the relationships (R) among factors that affected tuna production activities, including economic factors, catching production, characteristics of fishermen, and social factors. Generally, all relationship factors show a significant difference, reaching over 1.96 or <0.05, except correlation between social and catch production factor (R2), reaching only 1.227 with a significance of 0.220. In a statistic calculation, R3 becomes the highest relationship with a very far distance number of others, accounting for 21.366 and 0.00 ($p<0.05$). Meanwhile, R4 and R5 were determined to middle level by 1.339 with P values <0.05. In third place was R1, obtaining 2.295 and 0.022, revealing significant differences in the standard statistic calculation (T-statistic test). Finally, the non-significant number was generated by R2, reaching 1.227 and 0.220.

Furthermore, the model could be accepted, if the main indicator shows a good value in the model. There were five criteria that were used to measure the fit of the resulting model. According to Mourad and Valette-Florence (2016), SmartPLS provides bootstrap-based inferencing statistics from the SRMR criteria. Meanwhile, according to Sinkovics et al (2016) and Henseler et al (2015), there is also a fit model size, namely the d_ULS (Euclidean squared distance) and d_G (geodetic distance) criteria, which the d_G criterion is built on the calculation of the PLS-SEM eigenvalues. The fit model indicator could be estimated from the NFI value.

Table 5

Model fit estimation

	Saturated Model	*Estimated Model*
SRMR	0.106	0.124
d_ULS	1.028	1.403
d_G	0.727	0.807
Chi-Square	1,001.809	1,099.913
NFI	0.638	0.603

Table 5 shows that the SRMR value was 0.106, indicating that the model was adequate. According to Hoorper et al (2008), values that are less than 0.10 are categorized as suitable. The NFI criterion value also indicates that the model had a reasonable value, reaching 0.638 or 63.80 % of the resulting models. As a result, it could be concluded that the model was was relatively acceptable. According to Lohmöller (2013), generally, when the NFI number closes to 1, that means the model is more acceptable.

The analysis of the mediating variables was carried out after the model was found to be fit in order to determine the influence of the mediating variable had on the overall model. In this case, the effect of the variable of fishermen characteristics on catch production through the mediating variables of social and economic factors took responsibility. The results of the analysis showed that the effect of the mediating variable seemed insignificant, in which the t-statistic value, reaching 1.888 was smaller than the t-table value with 1.96. Moreover, It also appears that the P-value was greater than alpha (0.06 > 0.05). Thus, it could be concluded that the role of the mediating variables, such as social and economic factors, were not significant in increasing the production of skipjack tuna in Buhung Pitoe Island.

Table 6

Hypothesis testing

Hypotheses	*Hypothesis shape*	*Original sample (O)*	*Sample mean (M)*	*Standard deviation (STDEV)*	*T Statistics (|O/STDEV|)*	*P-Values*	*Decision (influence)*
H1	Characteristics of Fishermen > Catch Production	0.688	0.690	0.080	8.621	0.000	Significant
H2	Characteristics of Fishermen > Social Factors / Economic factors > Catch Production	-0.106	-0.108	0.056	1.888	0.060	Not significant
H3	Characteristics of Fishermen > Economic Factors	0.757	0.756	0.035	21.366	0.000	Significant
H4	Characteristics of Fishermen > Social Factors	0.612	0.608	0.061	9.960	0.000	Significant
H5	Economic factors > Catch Production	-0.224	-0.230	0.097	2.295	0.022	Significant

Hypotheses	Hypothesis shape	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T Statistics (|O/STDEV|)	P-Values	Decision (influence)
H6	Social Factors > Catch Production	0.103	0.112	0.084	1.227	0.220	Not significant

Table 6 presents the data, including relationship between factors, standard deviation, T-statistic test, and decision that were observed during study. Overall, the present study found that 4 hypothesis shape (H) showed a significant number ($p<0.05$), while the other 2 did not have a positive result ($p>0.05$). In case of significancy, there was an unproven hypothesis, revealed by H2 and H6, which statistically generated the p number to be higher than 0.05 and T-statistic value was lower than 1.96. However, H1, H3, H4, and H5 had different results that could showed a significant different statistically ($p<0.05$). Therefore, it could be concluded that a good model to be developed related to increasing the production of skipjack tuna on Buhung Pitoe Island was a model of the relationship between fishermen characteristics and catch production through economic factors. Meanwhile, the association between social elements and capturing production was an unrecommendable approach during the investigation using statistical methods ($p>0.05$). Furthermore, the model is presented in Figure 3 graphically.

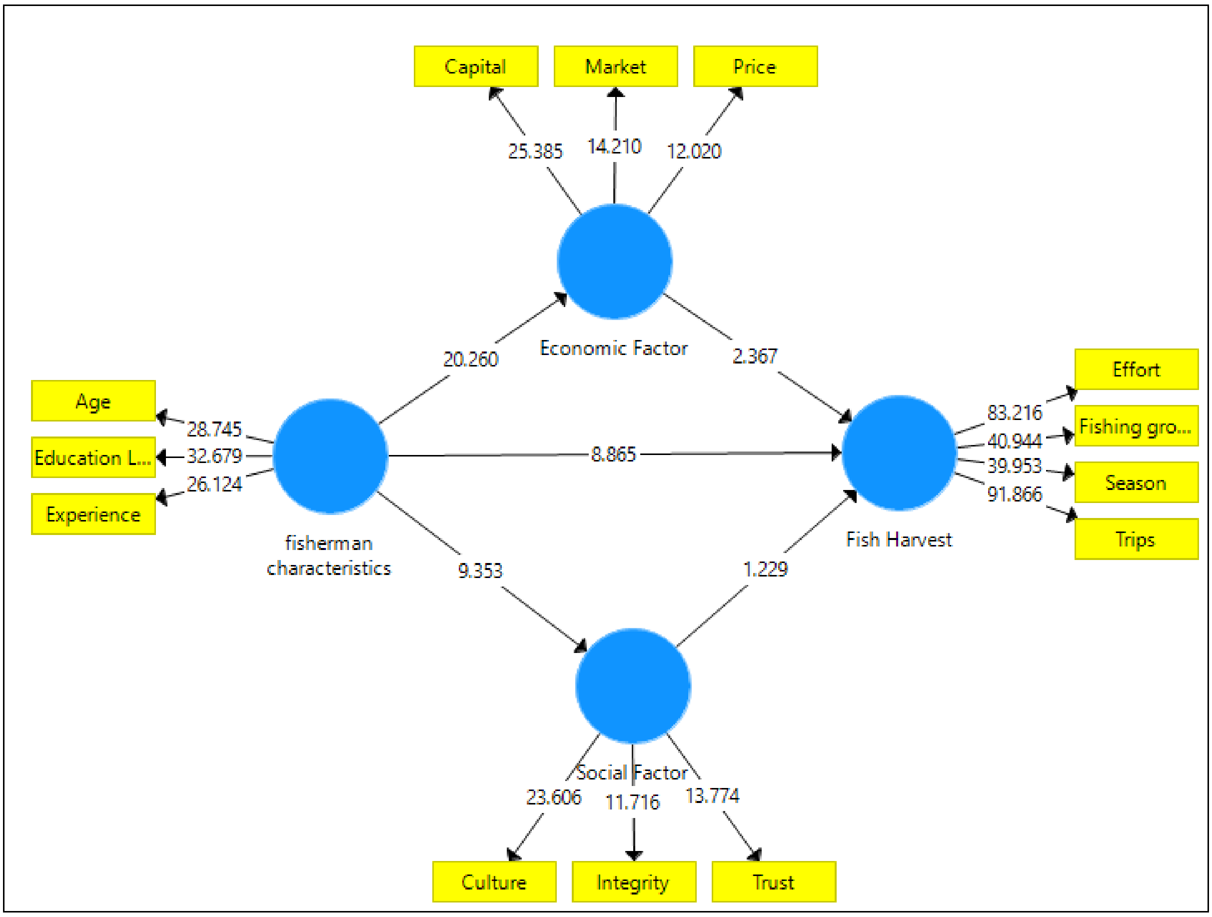

Figure 3. Bootstriping model.

Figure 3 explains various factors that affect tuna fish catching and reveals the better approach for increasing tuna production by fishermen. In general, the association between the economy approach and fishermen character showed significant method results, reaching 20.260 points, which was greater than the relationship between the fishermen and social factor, accounting for 9.353. Moreover, the economic side also most influenced the tuna catching compared to the social side (2.367 versus 1.229). Regarding those results, the development of tuna production in the Buhung Pitoe island through economic assistance is considered the best method.

Conclusions. The results showed that the average profit of fishermen in the peak season was IDR 41,812,500, while in the regular season was IDR 23,062,500. The fishing locations for skipjack tune were in the Bali, Flores and Lombok seas. The average fishing trip was around 16 days to 20 days per trip. The results of the hypotheses tests show that there are two unproven hypotheses, namely the H_2 hypothesis, and the H_6 hypothesis. As a result, it could be concluded that the relationship between fishermen and economic factors to be developed related to increasing the production of skipjack tuna on Buhung Pitoe Island.

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