The model of effective engagement of fishermen in conservation and management integration of squid fisheries in East Lombok Waters, Indonesia

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Abstract. East Lombok Regency is a major contributor to squid production in West Nusa Tenggara Province. However, habitat degradation and aquatic environmental damage have occurred in several locations that are potential fishing grounds for squid. The research aimed to (a) to analyze the trend of squid fisheries production and existing fisheries conservation programs, (b) to develop the model of effective fisherman engagement in the conservation of squid fisheries and the aquatic environment. This research used polynomial model, analysis of engagement level, and path analysis. Squid production in East Lombok Regency showed a fluctuating trend following a third-order polynomial pattern. The highest production occurred in 2017 (1,708.94 tons) and the lowest occurred in 2022 (547.46 tons). In 2019, the production reached 1,395.15 tons, but decreased in 2021 to 1,038.60 tons and decreased sharply in 2022. The existing fisheries conservation programs in East Lombok Regency were fisheries restocking, making and installing squid attractors, and regulating fishing patterns. The effective engagement models for fishermen in conservation programs are: (a) the engagement of fishermen as individuals was directed towards programs that prioritize participation, (b) the engagement of fishermen as groups was directed towards programs that prioritize participation and the impact of involvement, and (c) the engagement of fishermen as households was directed towards programs that focus on program effectiveness. The number of households and groups of fishermen involved significantly influenced the success of the conservation program.
Key Words: environment, path analysis, polynomial model, Tanjung Luar Port.

Introduction. West Nusa Tenggara (NTB) Province is one of the island provinces that has marine fisheries resources that have great potential to support community welfare and national development. Utilization of these resources needs to be carried out with the principles of sustainable development (sustainable development goals/SDGs). Daniela-Diz et al (2019) stated that the SDGs synergize the achievement of economic goals with environmental and social goals in every utilization activity. The goal is to maintain its continuity from generation to generation. Nationally, these SDGs targets have been integrated with National Medium-Term Development Plan (RPJMN) for 2020-2024, namely 124 targets (NDPA 2020), and in NTB, a Regional SDGs Center has been established. For this reason, various NTB fisheries activities should be managed well and prioritize sustainability principles. Fisheries management is a complex activity that regulates fish production activities, fisheries conservation, and the benefits of fisheries for the community, especially fishermen (Tikadar et al 2022; Sutomo et al 2011).

Squid fishing is one of the important fishing activities in NTB. The region with high production and the center of the squid fishery is East Lombok Regency. In 2021, East Lombok Regency's fisheries production reached 23,875.00 tons and squid contributed 1,038.60 tons (DMAF 2022). This production involved 16,371 fishermen, which is the largest fishing population among the 10 regions in NTB. However, squid production in East Lombok Regency has decreased significantly in the last 3 years. This decrease is

thought to be due to degradation of squid habitat and damage to the aquatic environment in several locations that are potential fishing areas (Mustaruddin et al 2022; Firdaus et al 2020). Field information stated that fishermen often encounter cases of squid eggs failing to hatch, rubbish and damaged coral reefs. The research results of Wahyudin et al (2019) and Marpaung et al (2015) also showed that the acidity in the waters of East Lombok Regency was relatively high (pH 8-9) and disrupts squid breeding.

Many conservation and fisheries management programs have been carried out, but have not succeeded in maintaining consistent squid production. Even though the intensity of the program has increased in the last five years (DMAF 2022; Firdaus et al 2020). Program failure could continue if local support is less than optimal, especially from fishermen. The fishermen of East Lombok Regency are full-time fishermen whose daily activities involve fishing. They live along the east and south coasts of Lombok Island. Around 95% of them are fishermen who catch squid, tuna, kites and lobsters. These fishermen are native fishers who live in coastal villages in East Lombok Regency. Referring to this, East Lombok Regency fishermen are prospective to be engaged in various fisheries conservation programs, because they have a real impact on squid production and the application of sustainable development principles in the fisheries sector. However, this engagement will only be effective if it is carried out in appropriate ways and according to program targets.

Therefore, it is necessary to conduct research on models of effective engagement of fishermen in conservation and fisheries management programs in East Lombok Regency. This was done by answering the research aims, namely: (a) analyzing the trend of squid fisheries production and existing fisheries conservation programs, (b) developing the model of effective fisherman engagement in conservation and management integration of squid fisheries with several program target scenarios.

Material and Method

Material and location. The materials and tools used consisted of questionnaires, stationery, and camera. This research was carried out in December 2023–February 2024. The location was Tanjung Luar Fishing Port and Jerowaru Fishing Center, East Lombok Regency, NTB.

Types of data and collection methods. The types of data collected consist of: (a) time series data on squid production in East Lombok Regency for the last 9 years, (b) data on conservation and fisheries management programs, (c) data on the distribution of fishermen's engagement in conservation and fisheries management programs, and (d) data on options for effective engagement of fishermen and program impacts.

Data collection methods were questionnaire distribution, direct observation, and literature study. Squid production time series data were collected through literature studies of fisheries statistics books, fisheries agency performance reports, and relevant study results. Data on conservation and fisheries management programs, data on fishermen's involvement in the program, and data on options for effective involvement of fishermen were collected using questionnaires and direct observation techniques. The questionaires were distributed to 15 fishermen, who were selected with the following criteria: (a) running an active fishing activity, (b) is fishing in coastal waters, and (c) squid is one of their main catches (Mustaruddin et al 2020; Aprian et al 2023).

Data analysis. Squid production trends in East Lombok Regency were analyzed using polynomial model. The model was chosen because it can explain the dynamics of the rise and fall of the object being studied calculatively over a specified time period (Kangkan et al 2022; Mustaruddin & Astarini 2019). In this study, the squid production time span for which trends were analyzed was 9 years (2014-2022). Data on conservation and fisheries management programs, and data on the distribution of fishermen's engagement in the program were analyzed using descriptive methods. For conservation and fisheries management programs, the descriptive method clearly described the names of fisheries conservation programs that had been implemented in the waters of East Lombok

Regency, the name of the initiator, and the year of implementation. The distribution of fishermen's engagement was described in each program. The distribution of engagement was assessed in four groups, namely not active, quite active, active and very active (Camp et al 2023; Lubis et al 2017).

The distribution of engagement was further analyzed to obtain a value that represented the engagement level of fishermen in each program. This engagement level (EL) analysis used the formula:

$$ES = (1x\ S_1)+(2xS_2)+\ldots+(nxS_n)$$
$$ES_{max} = n\ x\ (S_1+S_2+\ldots+S_n)$$
$$EL = ES/ES_{max}$$

where ES is the engagement score on the program, S_n is number of fishermen with the n^{th} activity in the program, ES_{max} is maximum engagement score on the program, i is 1, 2,…n, and EL is the engagement level of conservation and fisheries management programs. Determining the status of the engagement level of fishermen used five categories, namely: (a) EL=0–0.2 (very low); (b) EL=<0.2–0.4 (low); (c) EL=<0.4–0.6 (medium); (d) EL=<0.6–0.8 (high), and (e) EL=<0.8–1 (very high) (Field 2013).

The model of fishermen engagement in conservation and management integration of squid fisheries was prepared using path analysis. There were two paths analyzed, namely the path of influence of fishermen's engagement options on the number of participants in the program (Y) and the path of influence of fishermen's engagement options on the effectiveness of fishermen's engagement (Z). The engagement options offered were engagement as individual fishermen (X_1), fishing households (X_2), and fishing groups (X_3). The analysis model formula for both paths was prepared:

$$Y = b_1X_1+b_2X_2+b_3X_3+e_1$$
$$Z = aY+c_1X_1+c_2X_2+c_3X_3+e_2$$
$$\text{Total effect of } X_1 \text{ on } Z = b_1+(c_1a)$$
$$\text{Total effect of } X_2 \text{ on } Z = b_2+(c_2a)$$
$$\text{Total effect of } X_3 \text{ on } Z = b_3+(c_3a)$$

where b_1 is path coefficient of influence of X_1 on Y, b_2 is path coefficient of influence of X_2 on Y, b_3 is path coefficient of influence of X_3 on Y, c_1 is path coefficient of influence of X_1 on Z, c_2 is path coefficient of influence of influence of X_2 on Z, c_3 is path coefficient of influence of influence of X3 on Z, a is coefficient of the influence path of X_1, X_2, and X_3 through Y to Z, e_1=error on the path of influence on Y, and e_2=error on the path of influence on Z.

Path analysis results can be trusted (the model is accepted) if they have ANOVA value < 0.05 (significant) and R2 value > 0.90 (Seung 2016; Field 2013). The engagement option chosen as the model of effective involvement of fishermen in conservation and management integration of squid fisheries is one whose path coefficient is sig < 0.05 (Field 2013; Lehuta et al 2013).

Results and Discussion

Squid fisheries production and fisheries conservation program. Squid catching in East Lombok Regency used trolling rods, squid fishing rods, drift gillnets, boat charts, payangs, and squid angling (CSA 2022; MMAF 2022). This fishing gear was used by many fishermen, not only in East Lombok Regency but also in other regions in NTB. For boats, fishermen used outboard motor boats < 5 GT. The choice of fishing gear and boats differs in each region due to differences in fishing habits and seasonal patterns (Karnan et al 2012; Rosalina et al 2011). For example, fishermen in Tanjung Luar Fishing Port area used trolling rods and squid fishing rods, while in Jerowaru they used squid angling and gillnets to catch squid. In the abundant fish season, fishermen will choose fishing gear that is considered more effective (Nurani et al 2022) to increase their squid

production (Mustaruddin et al 2022; Hendri et al 2019). Squid production in East Lombok Regency for the 2014-2022 is presented in Figure 1.

Based on Figure 1, squid production (y) in East Lombok Regency fluctuated every year (x) following a polynomial pattern $y = -6.8329x^3+56.805x^2+33.139x+617.14$, with a tendency to decline sharply in the last 3 years (2020-2022). In 2020, squid production in East Lombok Regency reached 1,230.90 tons, in 2021 it decreased to 1,038.60 tons, and in 2021 it decreased again to 547.46 tons. Meanwhile, the fishing season and types of fishing gear used by fishermen were relatively the same in those years. The decline was thought to be due to the degradation of several potential fishing areas for squid (Mustaruddin et al 2022; Firdaus et al 2020), as well as damaged or polluted water environments (Wahyudin et al 2019; Marpaung et al 2015).

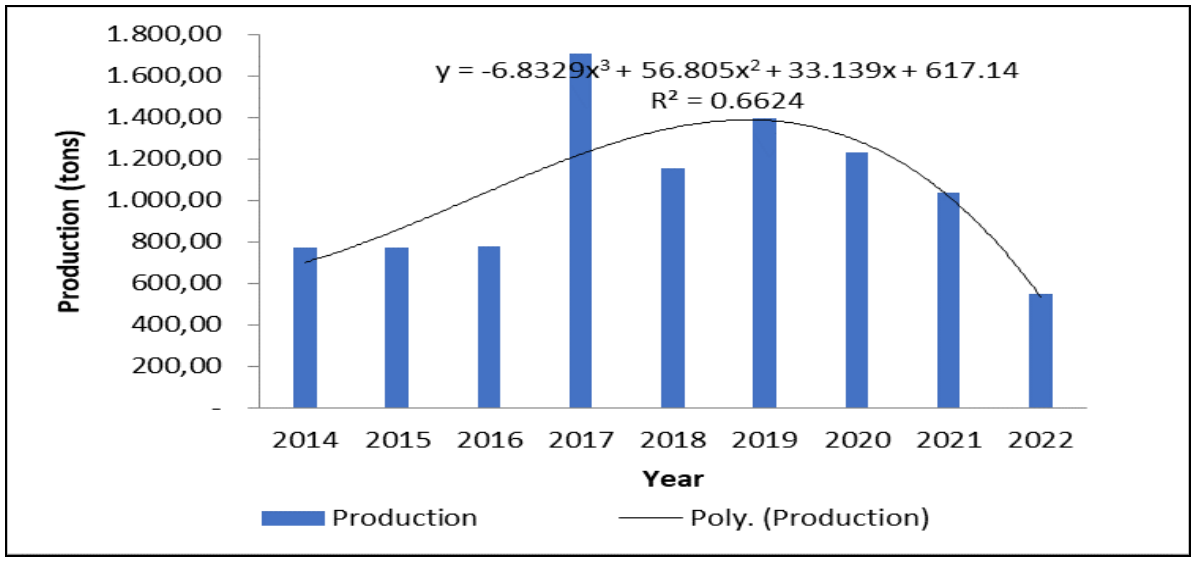

Figure 1. Squid production in East Lombok Regency 2014-2022.

Field information showed that increasing the intensity of coastal tourism was the main cause of degradation of fishing areas. Beach tourism was growing rapidly because of easy access to Lombok International Airport and the revitalization of tourist attractions on the east and north coast of Lombok Island (DTA 2022). Water pollution was generally caused by market activities, residential areas and hotels on the coast whose waste was discharged into the waters. This waste damaged the chemical-physical composition of water needed for the reproduction of squid and bottom fish (Halim et al 2022; Siregar et al 2016; Sindern et al 2016) and coastal plants (Kangkan et al 2022). Fisheries and aquatic environment conservation programs need to be intensified to maintain the existence of squid fisheries as an important commodity in East Lombok Regency (Mustaruddin et al 2022; Karnan et al 2012).

In 2017-2023, many conservation and fisheries management integration programs were carried out in East Lombok Regency. These programs included restocking fisheries, making & installing squid attractors, regulating fishing patterns, cleaning up rubbish on beaches and waters, transplanting coral reefs and conserving fish habitats, as well as fisheries research tourism (Table 1). Some of these programs were implemented repeatedly, such as programs to regulate fishing patterns, programs to clean up rubbish on beaches and waters, as well as coral reef transplantation programs and fish habitat conservation.

Table 1

Conservation and fisheries management integration programs 2017-2023

Programs	*Year*	*Initiator*
Fisheries restocking	2020	CMRMC of Denpasar, DMAF of NTB, PT. Nusa Tenggara Budidaya
Making & installing squid attractors	2022	CRDI/LPPM IPB University
Regulating fishing patterns	2020, 2021	NTB Government, MMAF of RI
Cleaning up rubbish on beaches and waters	2017, 2020, 2022	WCS, Village Government, Tanjung Luar Fishing Port Official
Transplanting coral reefs and conserving fish habitats	2019, 2022	National Electric Company, Regional Development Planning Agency of NTB, Fishermen's Institute
Fisheries research tourism	2018, 2023	Mataram Fish Quarantine Center, Ministry of Tourism and Creative Economy

Programs directly related to squid fisheries conservation were fisheries restocking programs, making and installing squid attractors, and regulating fishing patterns. The fisheries restocking program was held by Coastal and Marine Resources Management Center (CMRMC) of Denpasar, whose working area covers NTB Province. In 2020, this activity was carried out in East Lombok Regency, where the waters of Tanjung Luar and Jerowaru were also targeted because they support fisheries conservation in the Gili Sulat and Gili Lawang. Making and installing squid attractors was carried out by Community Research and Development Institute (CRDI) IPB University through a homecoming lecturer program (Mustaruddin et al 2022). Fishermen were very enthusiastic during the program, both in training, making practice, searching for practical supporting materials, and installing them in the waters. The program to regulate fishing patterns was carried out by the NTB Government in collaboration with the Ministry of Maritime Affairs and Fisheries of the Republic of Indonesia. Regulation of fishing patterns is needed to integrate (Daniela-Diz et al 2019) and limit fishing by certain fishing gear (Camp et al 2023; Hermanto et al 2019), thereby providing space for fish resources, including space for squid to breed (Tirtana et al 2020).

Level of fisherman engagement in the program. To develop the model of fishermen engagement in conservation and management integration of squid fisheries, it is necessary to review the engagement level that is currently occurring. This is important so that the model preparation is more useful and relevant to the actual conditions that exist. In general, the programs in Table 1 supported the conservation and management integration of squid fisheries, because they were interrelated and create a controlled aquatic environment. Fisheries research tourism supported the integration of marine conservation and fisheries management, even when undertaken in a relaxed, recreational setting (Miller 2022; Byrnes at al 2016). All of these programs engaged fishermen, although with different distributions of engagement (Figure 2).

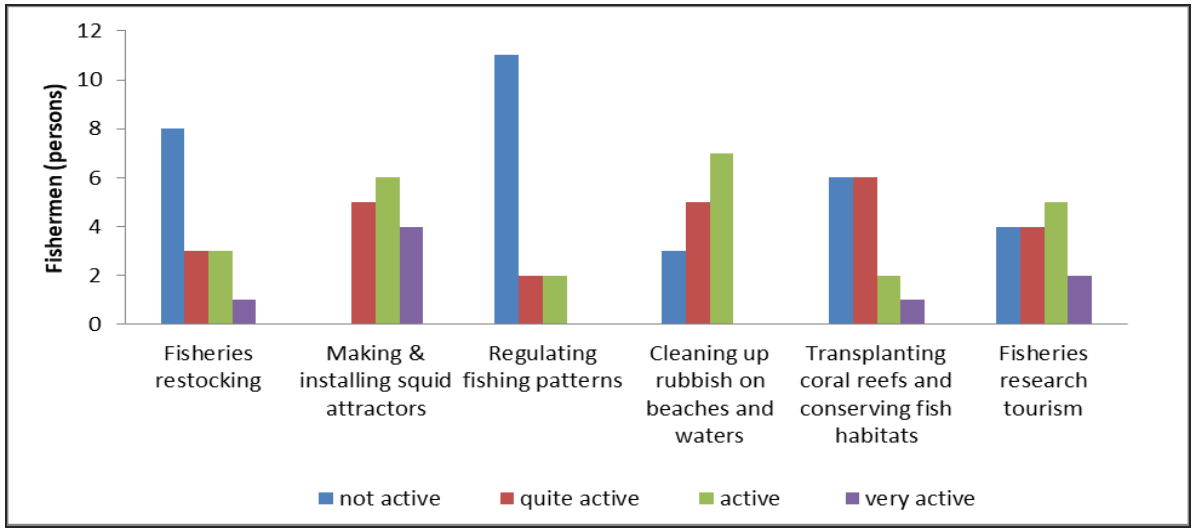

Figure 2. Distribution of fishermen's engagement in conservation and fisheries management integration programs.

Based on Figure 2, fishermen's engagement was generally at quite active or active status, and very few were at very active status. This is because fishermen are usually engaged in the program as participants and at the highest levels of the committee (Mustaruddin et al 2022; Lubis & Sembiring 2017). Engagement as a committee member is usually because fishermen have connections to the program initiator, for example the Fishermen's Institute, Department of Maritime Affairs and Fisheries (DMAF) of NTB, or Regional Development Planning Agency (RDPA) of NTB. The form of engagement can be individual, household or group. In the fishing pattern regulation program, fishermen are ussually invited individually and in groups, but are passive because they only hear the socialization and are also the direct targets of the program (Kusumawati & Huang 2015; Sutomo et al 2011). Table 2 presents the results of the engagement level analysis of fishermen in each program.

Table 2

Results of the engagement level analysis of fishermen in conservation and fisheries management integration programs

Programs	*1*	*2*	*3*	*4*	*ES*	*ES_{max}*	*EL*
Fisheries restocking	8	6	9	4	27	60	0.45
Making & installing squid attractors	0	10	18	16	44	60	0.73
Regulating fishing patterns	11	4	6	0	21	60	0.35
Cleaning up rubbish on beaches and waters	3	10	21	0	34	60	0.57
Transplanting coral reefs and conserving fish habitats	6	12	6	4	28	60	0.47
Fisheries research tourism	4	8	15	8	35	60	0.58
						Mean	0.53

Based on Table 2, the level of fishermen engagement in conservation and fisheries management integration programs was in the low to high category. A high level of fishermen engagement (EL = < 0.6–0.8) occurred in making and installing squid attractors (EL = 0.73). Medium level of engagement (EL = < 0.4–0.6) was the most engagement, occurring in fisheries research tourism programs (EL = 0.58), cleaning up rubbish on beaches and waters (EL = 0.57), transplanting coral reefs and conserving fish habitats (EL = 0.47), and fisheries restocking (EL = 0.45). Meanwhile, a low level of fishermen engagement (EL = < 0.2–0.4) occured in fishing pattern regulation programs (EL = 0.35). The difference in the fishermen engagement level was a common dynamic in responding to various programs targeting fishermen (Mustaruddin et al 2020; Lubis & Sembiring 2017).

Fishermen's response to the program was influenced by their interest and the way they were engaged in the program. According to Firdaus et al (2020) and Sutomo et al (2011), the most effective way of engaging fishermen in programs is through groups, whereas according to Kusumawati and Huang (2015) under certain conditions, engaging fishermen as individuals or households/families can be more effective. In general, the engagement level of fishermen in conservation and fisheries management integration programs held in East Lombok Regency was in the medium category (EL = 0.53). The category was good for fishermen with a low level of education (Yusuf et al 2022) and there were still conflicts of interest with other sectors. There were many conflicts of interest with the tourism sector, especially beach tourism which was carried out in the form of swimming, diving and snorkeling. These activities often touched water areas as potential fishing ground for squid (Mustaruddin et al 2022; Junaidi et al 2009).

The model of effective engagement of fishermen. The engagement of fishermen in conservation and fisheries management integration programs has the opportunity to increase, if done in the right ways. East Lombok Regency fishermen are still bound by local values (Yusuf et al 2022; Marpaung et al 2015), but are very open to accepting new things (Firdaus et al 2020). According to Wahyudin et al (2019) and Seung (2016), the program will be effective if it is able to raise understanding and awareness of fishermen. The participation pattern can be individual, household, or group according to the program targets. This condition was an important concern in preparing the fisherman engagement model in this research, and the results are presented in Figure 3.

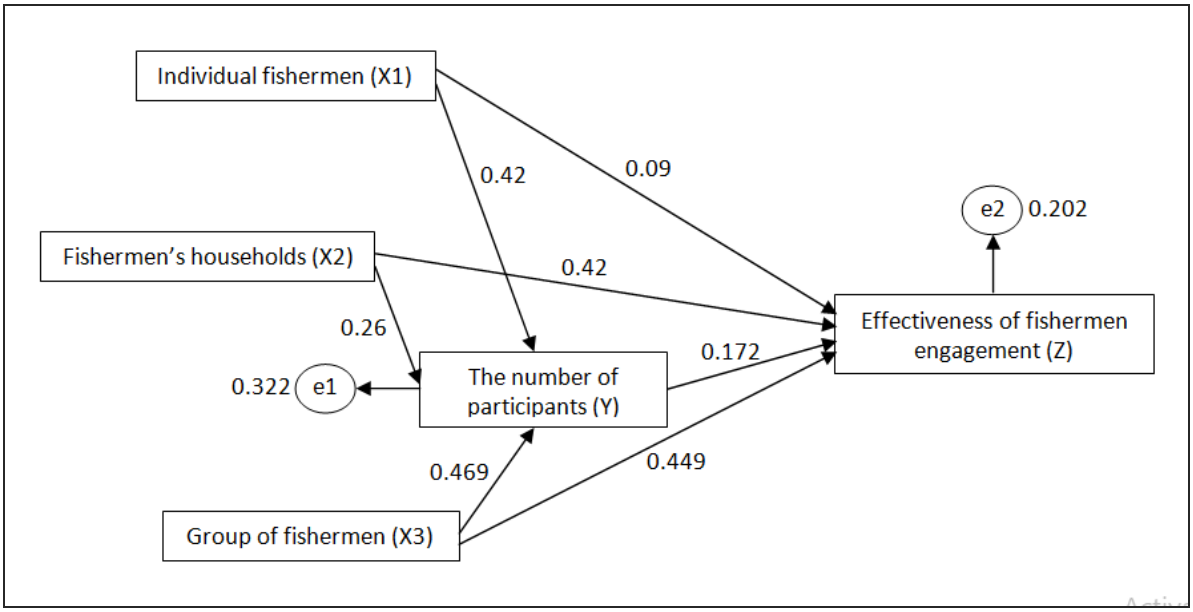

Figure 3. Model of effective engagement of fishermen in conservation and management integration of squid fisheries.

In the Figure 3 model, there were two main paths/targets for engaging fishermen in conservation and management integration of squid fisheries, namely optimizing the number of participants in the program (Y) and increasing the effectiveness of their engagement (Z). These two targets were scenario as benchmarks for the success of fishermen engagement options. Both paths had significant ANOVA values and good R^2 values, namely 0 and 0.9 for the influence path to Y, and namely 0 and 0.96 for the influence path to Z. Thus, the fisherman engagement model in Figure 3 was acceptable. Meanwhile, there were three options for engagement in the analysis, namely engaging fishermen individually, engaging fishermen as a family (household), and engaging fishermen as a group. These three options are a reflection of local values and ways for fishermen to engage themselves in various programs/activities (Yusuf et al 2022; Firdaus et al 2020; Lubis & Sembiring 2017). Table 3 presents the results of path 1 analysis,

namely the model for engaging fishermen to optimize the number of participants in the program.

Table 3

Results of analysis of fishermen engagement models to optimize the number of participants in the program

Model		*Coefficients*	*t*	*Sig.*
1	(Constant)		1.022	0.329
	X1	0.42	3.366	0.006
	X2	0.26	2.09	0.061
	X3	0.469	3.081	0.01

Note: dependent variable is the number of participants (Y).

Based on Table 3, engagement as individual fishermen (X1), fishing households (X2), and fishing groups (X3) could increase fishermen's participation in conservation and fisheries management integration programs, namely with coefficients of 0.42, 0.26, and 0.469 respectively. However, of the three engagement models, what significantly optimizes fishermen's participation in the program (Y) was their involvement as individual fishermen (X1) and their involvement as a group of fishermen (X3). This was indicated by a sig value < 0.05, namely 0.006 and 0.01 respectively.

Related to this, programs aimed at togetherness, solidarity and excitement in their implementation can invite fishermen individually and in groups to take part. It is easier to persuade individual fishermen to support the program (Garza-Gil et al 2015; Yusuf et al 2022), while groups are somewhat more difficult to persuade because they are bound by group rules, for example the customary law of awig-awig in Lombok. Awig-awig is a customary law that regulates the behavior of fishermen, especially those in large groups/scales, in utilizing fisheries resources (Firdaus et al 2020; Ayunda et al 2014). In Table 2, programs that prioritize togetherness and excitement include the program for cleaning up rubbish on beaches and waters, then the fisheries research tourism program. Table 4 presents the results of path 2 analysis, namely the engagement model to increase the effectiveness of fishermen engagement.

Table 4

Results of model analysis to increase the effectiveness of fishermen engagement

Model		*Coefficients*	*t*	*Sig.*
1	(Constant)		-2.431	0.035
	X1	0.09	0.762	0.464
	X2	0.42	4.295	0.002
	X3	0.449	3.259	0.009
	Y	0.172	0.861	0.409

Note: dependent variable is the effectiveness of fishermen engagement (Z).

The effectiveness of engaging fishermen was the final target of implementing every option for involving fishermen in conservation and fisheries management integration programs, both directly and indirectly. Increasing fishermen's participation in the program (Y) was an indirect indication, but its effectiveness in supporting the success of the program needed to be analyzed further. Based on Table 4, participation in the program (Y) had a positive effect on the effectiveness of fishermen engagement (Z), but it was not significant (sig > 0.05, namely 0.409). This means that large participation in conservation and management integration of squid fisheries in Tanjung Luar was not a guarantee of fishermen's effectiveness (program success). Effectiveness is determined by the actual output or achievement of the expected results in an activity (Mustaruddin et al 2022; Hendri et al 2019; Ayunda et al 2014).

Furthermore, the direct influence of the three fishermen engagement model options offered showed: (a) engagement as an individual fisherman (X1) could increase

the effectiveness of fisher engagement (Z) in the program with a coefficient of 0.09, but the increase was not significant (sig = 0.464), and (b) engagement as fishing households (X2) and fishing groups (X3) could significantly increase the effectiveness of engaging fishermen (Z) in the program as indicated by the sig values of 0.002 and 0.009 respectively. The model also showed that for programs that prioritize actual results, the impact of involvement, and the direct influence of the program, the engagement of fishermen as households and groups was prioritized. This was because households and groups are more burdened morally if the program is not successful (Garza-Gil et al 2015; Yusuf et al 2022) than fishermen as individuals. A good image is crucial for some households and groups of fishermen, especially small-scale fishermen groups bound by local values (Tikadar et al 2022; Firdaus et al 2020). Likewise, fishing groups/institutions, especially those that often gain trust, will always maintain their good image and role in society (Mustaruddin & Astarini 2019; Ayunda et al 2014). Therefore, the fishermen engaged will be serious and more responsible. Programs with characteristics like these in Tanjung Luar (Table 2) include fisheries restocking programs, making squid attractors & installing programs, and coral reef transplantation and fish habitat conservation programs.

Conclusions. The trend of squid production (y) in East Lombok Regency fluctuated every year (x) following an order 3 polynomial pattern with the formula $y = -6.8329x^3 + 56.805x^2 + 33.139x + 617.14$. The conservation and fisheries management integration programs directly related to squid in East Lombok Regency were fisheries restocking, making and installing squid attractors, and regulating fishing patterns. The level of fishermen engagement in the program was in the medium category (EL = 0.53, scale 0-1). The model of effective fisherman engagement in conservation and management integration of squid fisheries were : (a) for programs that prioritize the number of participants, fishermen need to be engaged as individual fishermen (sig = 0.006) and groups of fishermen (sig = 0.01), and (b) for programs that pursue the effectiveness/impact of engagement, fishermen need to be engaged as households (sig = 0.002) and groups of fishermen (sig = 0.009).

Acknowledgements. The author is deeply grateful to the Directorate of Innovation Research, IPB University who has helped fund this research through the Collaborative Research Program.

Conflict of interest. The authors declare that there is no conflict of interest.

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Received: 14 April 2024. Accepted: 02 March 2025 Published online: 21 November 2025.
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How to cite this article:
Mustaruddin, Puspito G., Suharyanto, Santoso D., 2025 The model of effective engagement of fishermen in conservation and management integration of squid fisheries in East Lombok Waters, Indonesia. AACL Bioflux 18(6):2507-2517.