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Operational and Strategic Factors Influencing Squid Catch Using Cast Nets at PPSNZ Jakarta, Indonesia

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ABSTRACT

This study aimed to analyze the factors influencing squid catch using cast nets and develop strategies for optimizing fishing operations at the Nizam Zachman Oceanic Fishery Port (PPSNZ), Jakarta, Indonesia. The research investigated the relationship between various operational factors, such as crew size, vessel size, engine power, fuel consumption, and fishing effort, with squid catch outcomes. Data were collected from 38 squid fishing vessels operating at PPSNZ over a period from 2019 to 2023. The results showed a significant increase in squid production, with a steady rise in catch volume over the years. However, despite the increase in fishing efforts, fluctuations in the catch per unit effort (CPUE) suggest that higher fishing effort does not always lead to proportional increases in catch, indicating inefficiencies in the fishing process. Regression analysis reveals that factors such as travel distance and fuel consumption significantly impact squid catch efficiency, explaining 97.1% of the variation in catch outcomes. Conversely, variables like crew size, vessel size, and lamp wattage were found to have minimal or no significant effect on catch efficiency. The study emphasizes the importance of optimizing operational processes and resource management to improve fishing productivity. The analysis of internal and external strategic factors suggests that leveraging the experience of fishermen, improving technological capabilities, and addressing weaknesses like inadequate navigation tools can enhance operational efficiency. Moreover, the study highlighted the growing demand for squid as a significant economic opportunity, while also acknowledging the challenges posed by rising operational costs. Recommendations include investing in navigation technology and fuel efficiency programs to improve sustainability and economic returns.

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INTRODUCTION

Indonesia, recognized as a maritime nation, is endowed with abundant marine resources. Approximately two-thirds of the country's territory is covered by oceans, underscoring the importance of fisheries to Indonesia’s economy **(Sari & Khoirudin, 2023)**. The fisheries sector plays a vital role, with capture fisheries serving as a primary means of utilizing marine resources, contributing a wide variety of species, including squid (*Loligo* sp.). Squid, in particular, holds significant economic value and ranks among Indonesia’s top fisheries products **(Purwanti *et al.*, 2024)**.

At the Nizam Zachman Oceanic Fishery Port (PPSNZ) in Jakarta, squid landings represent a substantial portion of national fisheries output, accounting for 53.8% of total landings in 2021. Despite consistent production levels, the industry continues to face challenges, particularly in maintaining post-harvest quality **(Kartika *et al.*, 2024)**. Cast nets, a common gear type used in squid fishing, are known for their effectiveness, especially when combined with light attractants such as Metal Halide (MH) lamps. Fishing vessels operating at PPSNZ typically use 16–20 lamps, producing a combined output of 24–30 kW to attract squid to the surface **(Rudin *et al.*, 2020)**.

Cast-net vessels are the third largest fleet after *bouke ami* and transport vessels at PPSNZ. A total of 757 ship-borne drop-net vessels operate at the port, unloading more than 5,000 tons of squid annually, valued at over IDR 200 billion. These vessels typically conduct two fishing seasons per year, with each voyage lasting between three to five months. However, despite their widespread use, the efficiency of cast nets varies significantly.

Several operational factors influence the success of squid fishing, including crew size, vessel size, engine power, fuel consumption, and fishing effort. Research indicates that these variables directly impact catch rates **(Nasution *et al.*, 2020)**. While engine power, crew size, and fishing duration are often assumed to be primary determinants of catch success, their actual effectiveness remains debated. Some studies suggest their impact on catch rates is minimal **(Hufiadi & Mahiswara, 2007)**. Conversely, fuel consumption and fishing distance are increasingly recognized as key factors affecting fishing efficiency **(Azizi *et al.*, 2017)**.

In addition to internal operational factors, the squid fishery at PPSNZ faces external challenges such as fluctuating market demand and rising operational costs. Despite high production levels, inconsistencies in catch per unit effort (CPUE) suggest that increased fishing efforts do not necessarily lead to higher yields, indicating potential inefficiencies in current fishing practices.

Given these circumstances, strategic interventions are essential to enhance operational efficiency and ensure the sustainability of squid fisheries. The integration of appropriate technologies and sound management practices is crucial to balancing commercial objectives with conservation goals.

Therefore, the interaction of these production factors not only influences squid yield but also plays a significant role in shaping the sustainability of marine resource management. This study aimed to identify the production factors that affect squid catch using cast nets and to develop strategic recommendations to improve the efficiency and sustainability of squid fisheries at PPSNZ, Jakarta.

MATERIALS AND METHODS

Study area

This research was carried out at the Nizam Zachman Ocean Fishing Port in North Jakarta, Indonesia, from June to August 2025. The study's location was identified through purposive sampling at Jl Tuna Raya No.1 Muara Baru Ujung, Penjaringan, North Jakarta. PPSNZ documented that 314 vessels employed ship-based drop net fishing gear, mostly targeting squid as their principal item. Furthermore, there exist alternative fishing equipments for capturing squid, comprising 265 vessels employing Bouke Ami and 281 vessels utilizing squid fishing rods. The catch commodities received at PPSNZ, in addition to squid, comprise tuna, lemuru fish, flying fish, tembang fish, skipjack tuna, and snapper.

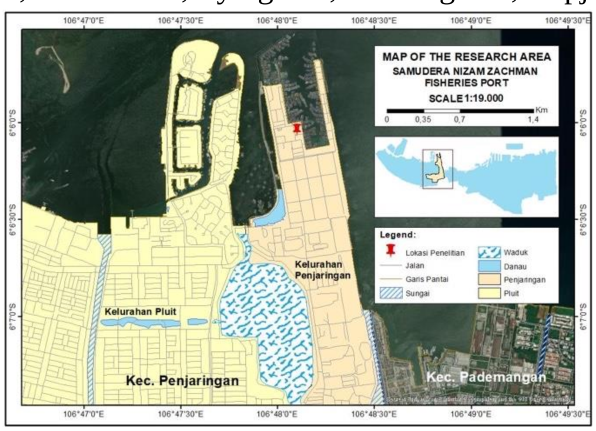

Fig. 1. Study area

Respondents and data collection method

This study employed the purposive sampling method. The purposive sampling methodology is a method that considers specific criteria. Sampling was conducted on squid net vessels engaged in loading and unloading operations at the Nizam Zachman Jakarta PPS. The sampling method employs the Slovin formula with a margin of error of 15%. A higher mistake rate corresponds to a smaller population, and vice versa. This study determined the sample size based on the approximately 314 squid net vessels engaged in loading and unloading at the Nizam Zachman Jakarta PPS in 2022. To determine the sample size, Slovin’s formula was used, which is given by:

$$Slovin's formula: n = \frac{N}{1 + Ne^2} = \frac{314}{1 + 314\,(0.15)^2} = 38$$

Description:

n = Sample size divided by the number of respondents

N = Size of the population (314 vessels)
E = Error tolerance (15%)

Given a margin of error of 15%, the sample size was calculated to ensure sufficient accuracy without over-sampling. This error tolerance was deemed acceptable because it provides a reasonable balance between statistical precision and practical feasibility, considering the scope and resources available for the study. Based on this calculation, we selected a sample of 38 vessels for further analysis.

The collected data sources comprised primary and secondary data. Primary data were acquired directly from sources without middlemen, encompassing both internal and external elements in this study. Secondary data originated from indirect sources, such as books, journal articles, and the internet. Secondary data included squid production volume, geographic location, and additional factors. The data were gathered through three methodologies: (1) Interviews, (2) Observations, and (3) Documentation.

Data analysis

The employed research method is descriptive, utilizing a mixed approach that integrates both quantitative and qualitative methodologies in scientific inquiry. The data analysis employed comprises regression analysis to examine the components influencing squid capture outcomes from vessels, while SWOT analysis is utilized to design a plan for advancing the fishing enterprise.

Regression analysis

The parameters influencing fish catch productivity were examined by multiple linear regression analysis. Regression analysis is a method for evaluating research hypotheses concerning the impact of one variable on another via a mathematical equation (regression). This investigation seeks to determine the parameters influencing fish catch productivity. The subsequent formula for multiple linear regression was utilized **(Sudariana & Yoedani, 2021)**.

$$Y = \alpha 0 + b1.\, x1 + b2.\, x2 + b3.\, x3 + b4.\, x4 + b5.\, x5 + \mu$$

Where:

Y = Catch (Kg/trip)
A = Intercept coefficient
b1 – b5 = Regression variable coefficient
X1 = Number of crew members (person)
X2 = Gross Tonnage (GT)
X3 = Engine Power (PK)
X4 = Quantity of hatches (bulbs)
X5 = Lamp power (watts)
X6 = Size of fishing gear (meters)
X7 = Distance traversed (miles)
X8 = Duration of trip (in months)
X9 = Fishing effort per trip (times)
X10 = Volume of fuel oil (liters)

The preliminary step before conducting further analysis was to transform the data into its natural logarithm (Ln) form. Once the transformation was completed, the data in natural logarithmic form were reanalyzed to derive a multiple linear regression equation. The general form of the equation is Y=a+bXY, which can also be expressed in its logarithmic form as Ln Q=a+b(Ln I). This formulation allows for interpretation based on elasticities and proportional relationships. If needed, the equation can be reverted to its original variables by exponentiating the logarithmic values.

Before interpreting the regression results, the standard assumptions of regression analysis were tested, including normality, multicollinearity, and heteroscedasticity:

a. Normality of residuals

The normality of the residuals was tested using the Kolmogorov–Smirnov (K–S) test. According to the test criteria, if the *P*-value obtained from the K–S test is greater than the significance level ($\alpha = 0.05$), the residuals are considered to follow a normal distribution. Conversely, a *P*-value below 0.05 would indicate a violation of the normality assumption.

Table (1) presents the results of the linear regression normality assessment based on the Kolmogorov–Smirnov test.

Table 1. Normality test result

	Unstandardized Residual
Test Statistic	.138
Asymp. Sig. (2-tailed)	.066[c]

b. To identify multicollinearity, the Variance Inflation Factor (VIF) value was verified to be greater than 10, which suggests that the model is devoid of multicollinearity. The results of the multicollinearity test are shown in Table (2).

Table 2. Multicollinearity test result

Independent variables	**Tolerance**	**VIF**	**Conclusion**
Number of crew member (X1)	.557	1.796	No multicollinearity
Gross Tonnage (X2)	.235	4.248	No multicollinearity
Engine power (X3)	.394	2.536	No multicollinearity
Quantity of hatches (X4)	.688	1.454	No multicollinearity
Lamp power (X5)	.114	8.807	No multicollinearity
Fishing gear size (X6)	.191	5.243	No multicollinearity
Distance traversed (X7)	.091	9.975	No multicollinearity
Duration of trip (X8)	.255	3.928	No multicollinearity
Fishing effort per trip (X9)	.579	1.726	No multicollinearity
Volume of fuel oil (X10)	.109	9.140	No multicollinearity

Table (2) indicates that the VIF values for all variables are devoid of multicollinearity, as they are below 10.

c. The aim of assessing the heteroscedasticity assumption is to ascertain if the outcomes of the linear regression model exhibit a uniform (constant) variance. Non-heteroscedasticity in linear regression was assessed by analyzing a scatterplot. A homogenous variance is deemed present when the residual points on the scatterplot are dispersed randomly. Fig. (2) displays the outcomes of the heteroscedasticity test.

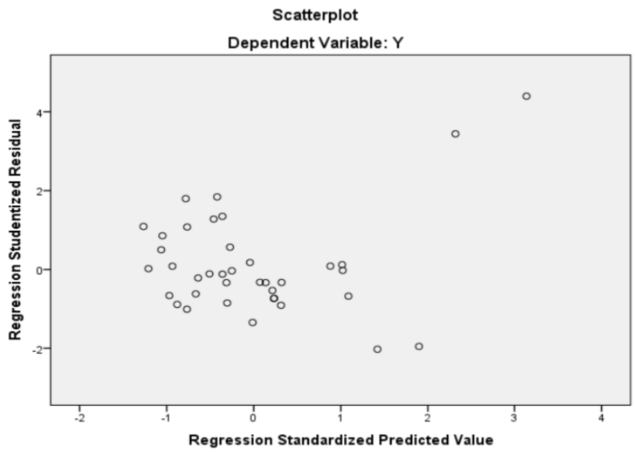

Fig. 2. Heteroscedasticity test result

The scatterplot indicates that the assumption of non-heteroscedasticity is satisfied, as the residual points appear randomly distributed. This pattern suggests homogeneity of variance in the residuals, indicating that the heteroscedasticity assumption in the regression model has not been violated. Consequently, the regression model meets the requirement for homoscedasticity.

Strategic business development

The SWOT analysis was conducted through the following steps:

1. **Assigning weights and ratings in the internal factor evaluation (IFE) and external factor evaluation (EFE) matrices**

An internal and external environmental analysis was carried out by assigning weights to each factor based on its relative importance, using a Likert scale. After assigning the weight, each factor was then rated on a scale of 1 to 4, reflecting the company's current condition with respect to that factor. The final weighted scores for both the IFE and EFE matrices were obtained by multiplying the weights by the corresponding ratings **(Anandya *et al.*, 2025)**.

2. SWOT matrix

The SWOT Matrix is a strategic tool used to integrate a company's internal strengths and weaknesses with external opportunities and threats. The matrix produces four types of strategic alternatives:

- **SO (Strength–Opportunity) Strategies**
- **WO (Weakness–Opportunity) Strategies**
- **ST (Strength–Threat) Strategies**
- **WT (Weakness–Threat) Strategies**

These alternatives help guide decision-making for business development and future planning.

RESULTS AND DISCUSSION

Potential for squid fishing utilizing cast nets

The squid catch using boat drop nets has consistently increased from 2019 to 2023 (Table 3). The data illustrate the trends in Catch Per Unit Effort (CPUE) for squid fishing vessels operating with the boat drop net method during this period. Total production rose significantly, from 538,598 kg in 2019 to 726,373 kg in 2023, in parallel with an increase in the number of fishing trips, reflecting higher fishing effort over time.

However, despite the rise in both production and effort, CPUE showed variability. The highest CPUE was recorded in 2020 at 101.53 kg/trip. This was followed by a decline in 2021 and 2022, before experiencing a modest rebound to 91.09 kg/trip in 2023. These fluctuations suggest that increased fishing effort does not always result in proportional gains in catch efficiency. The variation in CPUE may be attributed to environmental changes, shifts in squid population dynamics, or differences in fishing techniques and gear performance **(Hoggarth *et al.*, 2006)**.

Table 3. Statistics on squid production by vessel from 2019 to 2023

Year	Production (kg)	Fishing Effort (Trip)	CPUE (kg/Trip)
2019	538,598	5,313	101.37
2020	559,026	5,506	101.53
2021	591,273	6,642	89.02
2022	631,897	7,368	85.78
2023	726,373	7,974	91.09
Total	**3,047,167**	**32,803**	**468.78**
Average	**609,433.9**	**16,401.5**	**234.39**

Source: Secondary Data (2025).

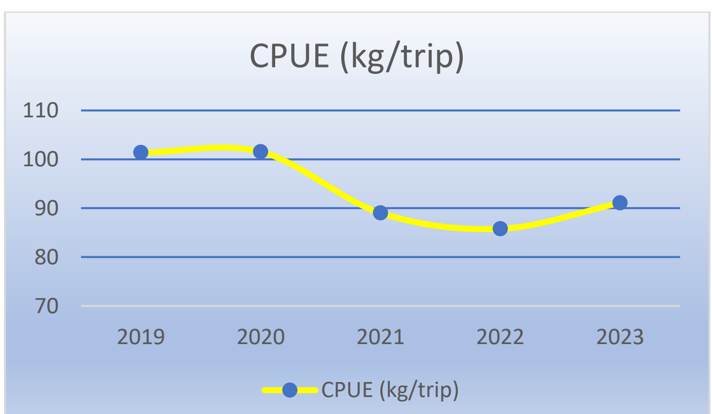

Fig. 3. CPUE of squid (kg/trip)

The presence of CPUE variations (Fig. 3), despite increased production and fishing effort, highlights the importance of fishing efficiency—an aspect that cannot be fully explained by the frequency of trips or the total catch volume alone. The decline in CPUE observed in 2021 and 2022 may indicate a decline in resource quality or changes in squid migration patterns, both of which can affect catch per trip. Numerous studies have emphasized that CPUE is influenced by a variety of factors, including fishing techniques, aquatic environmental conditions, and inadequate natural resource management **(Gebremedhin *et al.*, 2021)**. Therefore, even amid increased production and effort, CPUE as an efficiency indicator must be critically evaluated to support the sustainable management of fishery resources.

Determinants influencing catch outcomes

The factors affecting squid catch using ship-based drop nets were analyzed through multiple linear regression using SPSS software. The analysis was conducted using data from 38 squid fishing vessels operating with cast nets. The study identified ten key indicators that influence squid (*Loligo* sp.) catch volumes:

1. Number of crew members (ABK, persons)
2. Gross Tonnage (GT)
3. Engine power (PK)
4. Number of hatches
5. Lamp power
6. Fishing gear size
7. Distance traveled (miles)
8. Duration of trip (months)
9. Fishing effort per trip (number of times)
10. Volume of fuel used (liters)

Coefficient of determination (R^2 Test)

The coefficient of determination (R^2) measures how much of the variation in the dependent variable (Y—squid catch) can be explained by the independent variables (Xi). The R^2 value serves as an indicator of the model's explanatory power. The R^2 values generated from SPSS output are presented in Table (4).

Table 3. Analysis of R^2 determination test results

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.986[a]	.971	.961	1458.776

a. Predictors: (Constant), Number of crew members (X1), Gross Tonnage (X2), Engine power (X3), Quantity of hatches (X4), Lamp power (X5), Fishing gear size (X6), Distance traversed (X7), Duration of trip (X8), Fishing effort per trip (X9), and Volume of fuel oil (X10)

According to Table (4), the coefficient of determination (R^2) is 0.971, or 97.1%. This indicates that the independent variables—number of crew members (X_1), gross tonnage (X_2), engine power (X_3), number of hatches (X_4), lamp power (X_5), fishing gear size (X_6), distance traversed (X_7), duration of trip (X_8), fishing effort per trip (X_9), and volume of fuel oil (X_{10})—collectively explain 97.1% of the variation in squid catch (Y). The remaining 2.9% is attributed to other factors not included in this study.

F-test

The F-test is used to evaluate whether all the independent variables (Xi) collectively have a statistically significant effect on the dependent variable (Y). The results of the F-test, generated from SPSS output, are summarized in Table (5).

Table 4. Outcomes of concurrent regression analysis

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1956641860.000	10	195664186.000	91.946	.000[b]
	Residual	57456764.600	27	2128028.319		
	Total	2014098625.000	37			

a. Dependent Variable: Catch (Y)]
b. Predictors: (Constant), Number of crew members (X1), Gross Tonnage (X2), Engine power (X3), Quantity of hatches (X4), Lamp power (X5), Fishing gear size (X6), Distance traversed (X7), Duration of trip (X8), Fishing effort per trip (X9), and Volume of fuel oil (X10)

According to Table (5), the significance value for the simultaneous influence of the independent variables—number of crew members (X_1), gross tonnage (X_2), engine power (X_3), number of hatches (X_4), lamp power (X_5), fishing gear size (X_6), distance traversed (X_7), duration of trip (X_8), fishing effort per trip (X_9), and volume of fuel oil (X_{10})—on the catch (Y) is 0.000, which is less than the significance threshold of 0.05. Additionally, the calculated F-value (F count) is 91.946, which is greater than the F-table value of 2.20.

These results indicate that the independent variables collectively have a statistically significant effect on squid catch volume. Therefore, the regression model is valid for explaining the relationship between the identified factors and catch outcomes.

t-test

The t-test was conducted to evaluate the partial effect of each individual production factor on squid catch volume. The analysis was performed using SPSS, and the results are presented in Table (6).

Table 5. Outcomes of partial regression analysis

Model		t	Sig.	Collinearity Statistics Tolerance	VIF	Summary
1	(Constant)	-4.401	.000			
	Number of crew member (X1)	.289	.775	.557	1.796	✗
	Gross Tonnage (X2)	2.006	.055	.235	4.248	✗
	Engine power (X3)	-1.620	.117	.394	2.536	✗
	Quantity of hatches (X4)	-1.232	.228	.688	1.454	✗
	Lamp power (X5)	-.579	.568	.114	8.807	✗
	Fishing gear size (X6)	-.894	.379	.191	5.243	✗
	Distance traversed (X7)	6.483	.000	.091	9.975	✓
	Duration of trip (X8)	.146	.885	.255	3.928	✗
	Fishing effort per trip (X9)	.985	.333	.579	1.726	✗
	Volume of fuel oil (X10)	3.388	.002	.109	9.140	✓

Coefficients[a]

a. Dependent Variable: Catch (Y)

Additional information: 1. Crosses (✗): non significant; and 2. Checkmarks (✓): significant

The calculation requirements for this partial test indicate that if the t-value exceeds the t-table or the *P*-value is less than the level of significance ($\alpha = 5\%$), then each production element is deemed to significantly influence the squid capture aboard the boat at PPSNZ Jakarta. This text elucidates the t-test utilized to identify the parameters affecting the squid capture aboard the vessel at PPSNZ.

1. The influence of the number of crew member on the catch results

The *P*-value for the effect of the number of crew members (X_1) is 0.775, which exceeds the 0.05 threshold, and the t-value is 0.289, less than the critical t-table value of 2.051. Therefore, H_1 is rejected and H_0 is accepted, indicating that the number of crew members does not significantly affect the squid catch (Y) using cast nets at PPSNZ Jakarta. Crew size across vessels ranged from 9 to 18 individuals, and operations typically involved casting nets once per night, with 2–3 retrievals using a *gardan* tool. Research by **Suwarso *et al.* (2019)** suggested that squid abundance in the Sunda Shelf waters showed no significant difference between areas using *bouke ami* and cast nets—highlighting that gear design and technique may play a more critical role than crew size.

2. Influence of gross tonnage (X_2) on catch

Gross tonnage had a p-value of 0.055, slightly above 0.05, and a t-value of 2.006, which is below the critical value of 2.051. Thus, H_1 is rejected and H_0 is accepted, indicating no significant effect of gross tonnage on squid catch (Y). This aligns with findings by **Rousseau *et al.* (2019)**, which showed that global fleet expansions have not translated into higher CPUE, pointing to broader management and sustainability issues affecting fish stocks.

3. Influence of engine power (X_3) on catch

The engine power variable yielded a p-value of 0.117 and a t-value of -1.620, both indicating non-significance. Hence, H_1 is rejected and H_0 is accepted. Research by **Wang *et al.* (2021)** on fisheries in China noted similar trends: increasing horsepower did not result in higher squid catches, largely due to overexploitation and resource decline outweighing technological gains.

4. Influence of quantity of hatches (X_4) on catch

The number of hatches had a p-value of 0.228 and a t-value of -1.232, both failing to meet significance criteria. Therefore, H_1 is rejected and H_0 is accepted. Studies have indicated that fish hold capacity has little effect on catch quantity, compared to operational expertise, fishing technology, and environmental factors **(Wu *et al.*, 2024)**.

5. Influence of lamp power (X_5) on catch

The *P*-value for lamp wattage was 0.568, and the t-value was -0.579, both indicating a lack of significance. Thus, H_1 is rejected and H_0 is accepted. **Wang *et al.* (2024)** found that while LED lamps may improve visibility, catch efficiency was more affected by spectral properties and light placement than by wattage alone.

6. Influence of fishing gear size (X_6) on catch

A *P*-value of 0.379 and a t-value of -0.894 suggest no significant influence of gear size on catch (Y). Consequently, H_1 is rejected and H_0 is accepted. Research by **Talukdar *et al.* (2024)** emphasized that the method and timing of gear deployment outweighed net size in determining catch success.

7. Influence of distance traversed (X_7) on catch

The distance traveled variable was statistically significant, with a *P*-value of 0.000 and a t-value of 6.843, exceeding the critical threshold. Hence, H_1 is accepted and H_0 is rejected, indicating a strong positive relationship. According to **Kamarulzaman and Jumain (2023)**, greater fishing distances often correlate with better yields, likely due to accessing less exploited or more productive fishing zones.

8. Influence of trip duration (X_8) on catch

Trip duration showed a *P*-value of 0.885 and a t-value of 0.146, failing significance tests. Thus, H_1 is rejected and H_0 is accepted. **Primitivo *et al.* (2020)** found that fishing season and ecological factors are more influential than duration, with catch rates tied more closely to biological rhythms than time spent at sea.

9. Influence of fishing effort per trip (X_9) on catch

The *P*-value for fishing effort per trip was 0.333, and the t-value was 0.985, both statistically insignificant. Therefore, H_1 is rejected and H_0 is accepted. **Birdsong *et al.* (2021)** emphasized that fishing success depends more on biological and environmental conditions than on the number of fishing efforts.

10. Influence of fuel volume (X_{10}) on catch

Fuel volume had a statistically significant p-value of 0.002 and a t-value of 3.388, exceeding the critical t-value. Thus, H_1 is accepted and H_0 is rejected, indicating a meaningful effect. According to **Ferrer *et al.* (2021a)**, fuel use affects fishing efficiency and profitability. They observed that declining biomass forces fishers to use more fuel for diminishing returns, linking fuel use to sustainability challenges.

Business strategy for cast net squid fishing

Based on the analysis of production factors influencing squid catch efficiency, the following section outlines strategic development measures to enhance both productivity and sustainability in the *jala jatuh* (cast net) fisheries at PPSNZ Jakarta. Emphasis is placed on the integration of:

- Technological innovation
- Capacity building for fishers
- Regulatory and policy support

These strategies aim to optimize operations, improve yield, and safeguard marine resources. They are grounded in empirical data and are tailored to address biological constraints (e.g., resource depletion) and socioeconomic challenges (e.g., rising fuel costs).

Internal and external strategic factors

The identification of strategic priorities begins with the Internal Factor Evaluation (IFE) Matrix, which aggregates and scores internal strengths and weaknesses. The scoring results are presented in Table (7).

Table 6. Matrix of IFE

	Internal Strategic Factors	Weight	Rating	Score
Strengths				
1	Fishermen's experience in fishing for more than 10 years	0.17	3.87	0.67
2	Profitable squid selling price	0.16	3.47	0.54
3	Adequate facilities and infrastructure	0.12	2.77	0.34
4	Labor availability	0.13	2.97	0.40
5	Negative impacts on the environment are often minimal	0.14	3.03	0.41
Total of Strengths				**2.36**
Weaknesses				
1	Insufficient educational attainment among fishermen	0.07	1.67	0.13
2	Lack of ownership of navigation tools	0.11	2.50	0.28
3	Insufficient proficiency in technology and information	0.09	2.03	0.18
Total of Weaknesses				**0.59**
The difference between Total Strengths – Total Weaknesses (x)				**1.77**
Total of IFE				**2.95**

Internal strategic factors encompass both strengths and weaknesses that influence the effectiveness of squid fishing operations using cast nets. Based on the scoring presented in Table (7), the most significant strength is the fishermen's expertise in fishing activities exceeding 10 years. This long-term experience represents a valuable asset, as it equips fishers with essential skills and insights into fish behavior, seasonal patterns, and local ecosystems.

According to **Amadu *et al.* (2021)**, the expertise of artisanal fishermen plays a critical role in their livelihood resilience. Experienced fishers are better equipped to adapt to changing environmental conditions and market demands, thereby increasing their catch success. Their in-depth understanding of migratory patterns, habitat preferences, and optimal fishing strategies enables them to execute operations with greater precision and efficiency, ultimately leading to improved yields.

On the other hand, the most significant weakness identified is the lack of ownership of navigation tools. The absence of navigational equipment among fishers represents a major limitation, adversely impacting both safety and operational performance. Modern navigation systems are essential for enhancing route efficiency, locating productive fishing grounds, and avoiding hazardous conditions.

While **Danielsen (2022)** does not focus specifically on fishing operations, the study emphasizes the importance of well-designed ship bridge systems for improved interaction between navigators and technology. By extension, this underscores the value of integrating navigation tools into fishing vessels. Without such tools, fishers may struggle with effective location tracking and fail to optimize routes, leading to reduced catch efficiency. Moreover, reliable navigation equipment provides crucial data on weather patterns and sea conditions, contributing to safer and more productive fishing activities.

Table 7. Matrix of EFE

	External Strategic Factors	Weight	Rating	Score
Opportunities				
1	There exists a Fish Auction Place (TPI)	0.19	3.23	0.61
2	The demand for squid continues to increase	0.19	3.33	0.65
3	There is collaboration and assistance from the government	0.14	2.43	0.35
4	Access to external funding sources	0.13	2.17	0.28
Total of Opportunities				**1.88**
Threats				
1	Increase in prices of sea supplies	0.18	3.07	0.55
2	Fishing depends on the season and weather	0.17	2.87	0.48
Total of Threats				**1.03**
The difference between Total Opportunities – Total Threats (y)				**0.85**
Total of EFE				**2.91**

External strategic factors consist of opportunities and threats that can significantly affect the success and sustainability of squid fishing operations using cast nets.

Based on Table (8), the most significant opportunity is the increasing demand for squid. Both domestically and internationally, consumer demand for squid has been rising, presenting substantial economic potential for fishers. According to **Afiati *et al.* (2022)**, cephalopods—including squid—accounted for approximately 13–14% of total global fisheries landings from 2000 to 2019. With global consumption trends favoring seafood, particularly in Asia where squid is regarded as a culinary delicacy, demand is expected to continue increasing. This trend encourages fishers to invest in enhancing their operations to meet market needs and seize the economic benefits.

In contrast, the most significant threat identified is the rising cost of sea supplies, particularly fuel prices. In Indonesia, subsidized diesel is essential for operating fishing vessels. Increases in fuel prices directly threaten the economic viability of small-scale fishing operations. According to **Al Fajrin *et al.* (2023)** and **Kaaji *et al.* (2024a)**, fluctuations in fuel prices reduce fishermen's profit margins and challenge their economic sustainability. Affordable fuel access is critical for maintaining competitive and efficient fishing operations. When fuel costs rise, operational expenses surge, reducing profitability and potentially limiting fishing activities.

Moreover, other essential supplies—such as nets, ice, and maintenance materials—have also seen rising costs. The price increases compound the financial burden on fishers. Although **Fajrin *et al.* (2023)** mainly explored the broader economic impacts of rising fuel costs, the implication remains clear: increasing input prices—especially those tied to fuel—threaten the sustainability of fishing operations reliant on cast net technologies.

Comparative analysis of internal and external factors

Referring to Tables (5, 6), the total Internal Factor Evaluation (IFE) score is 2.95, while the External Factor Evaluation (EFE) score is 2.91. This indicates that internal factors exert slightly more influence than external factors on the performance of squid fisheries using cast nets.

A higher IFE score suggests that the organization—or in this case, the fishing operations—possess relatively strong internal capabilities. According to **Leliga *et al.* (2019)**, an IFE score above 2.5 signifies a solid internal position, meaning the organization is well-equipped to leverage its strengths. In the context of squid fishing, this implies that the fishers are in a favorable position to enhance their operations by improving internal factors such as:

- Upgrading fishing equipment and vessel technology
- Enhancing crew training and skill development
- Streamlining fishing practices and operational planning

By capitalizing on these internal strengths, fishers can improve productivity and resilience while mitigating external threats, such as rising costs or market fluctuations. This strategic advantage provides a strong foundation for sustainable business development in the squid fishing sector.

Formulation of development strategy for squid fishing business by cast net

Fishermen, boat operators, and relevant stakeholders must use their strengths and opportunities while mitigating their vulnerabilities and risks to formulate alternative strategies for the development of squid fishing business policies. Utilizing the IFAS and EFAS analysis, alternative methods are developed to enhance the productivity and revenue of squid fishermen operating boats, as illustrated in Table (9) through SWOT analysis.

Table 8. SWOT matrix

Internal Factors / **External Factors**	**Strengths** 1) Fishermen's experience in fishing for more than 10 years (S1) 2) Profitable squid selling price (S2) 3) Adequate facilities and infrastructure (S3) 4) Labor availability (S4) 5) Negative impacts on the environment are often minimal (S5)	**Weaknesses** 1) Insufficient educational attainment among fisherman (W1) 2) Lack of ownership of navigation tools (W2) 3) Insufficient proficiency in technology and information (W3)
Opportunities 1) There exist a Fish Auction Place (TPI) (O1) 2) The demand for squid continues to increase (O2) 3) There is collaboration and assistance from the government (O3) 4) Access to external funding sources (O4)	**Stratgi SO:** 1) Leverage Experienced Fishermen for Expansion 2) Develop Strong Partnership with Government 3) Enhance Sales and Marketing Channels	**Strategi WO:** 1) Improve Technological Capability through External Collaboration 2) Training and Education for Fishermen
Threats 1) Increase in prices of sea supplies (T1) 2) Fishing depends on the season and weather (T2)	**Strategi ST:** 1) Optimize Operational Costs to Combat Rising Prices 2) Diversify Product Offering	**Strategi WT:** 1. Invest in Technological and Infrastructure to Overcome Vulnerabilities

Table 9. SWOT strategies and actionable steps

Strategy type	Alternative strategies	Actionable steps
SO	Leverage Experienced Fishermen for Expansion	Identify high-demand markets (O2) and deploy experienced fishermen (S1) to meet demand
	Develop Strong Partnership with Government	Collaborate with local agencies (O2) to secure funding or subsidies for infrastructure (S3, S5)
	Enhance Sales and Marketing Channels	Partner with Fish Auction Place (TPI) (O1) to expand distribution using profitable pricing (S2)
WO	Improve Technological Capability through External Collaboration	Seek government grants (O4) to train fishermen (W1) on navigation tools (W2) and tech (W3)
	Improve Technological Capability through External Collaboration	Organize workshops with NGOs/government (O3) to address literacy gaps (W1) and tech skills (W3)
ST	Optimize Operational Costs to Combat Rising Prices	Bulk-purchase sea supplies (S4) to offset price hikes (T1); maintain equipment (S3) for efficiency
	Diversify Product Offering	Use off-seasons (T2) to process squid into value-added products (e.g., dried squid) (S1, S2)
WT	Invest in Technological and Infrastructure to Overcome Vulnerabilities	Secure external funding (O4) to buy navigation tools (W2) and weather-tracking systems (T2)

Alternative strategies for squid fishing using cast nets (Table 10)

The SWOT analysis produced four strategic categories—SO, ST, WO, and WT—each combining internal and external factors to develop actionable approaches for improving squid fishing operations at PPSNZ Jakarta.

1) SO (Strengths–Opportunities) strategies

a. Leverage experienced fishermen for expansion

Utilize the experienced workforce—fishers with more than 10 years of expertise—to scale up operations and meet rising market demand. Offering specialized training can further enhance skills, ensure catch quality, and increase output to capitalize on the opportunity of growing squid demand.

b. Develop strong partnerships with government

Maximize government support and external funding opportunities to upgrade fishing infrastructure and onboard technologies, improving overall efficiency and reducing operational costs.

c. Enhance sales and marketing channels

Leverage profitable squid prices by exploring new sales outlets, including fish auction sites and export channels, to expand market reach and improve price stability.

2) ST (Strengths–Threats) strategies

a. Optimize operational costs to combat rising prices

Utilize the internal strength of adequate labor and infrastructure to streamline operations and increase cost-efficiency, helping to counteract rising prices of maritime supplies.

b. Diversify product offerings

To reduce vulnerability to seasonal and weather-related variability, explore product diversification strategies, including targeting other species or producing value-added items such as processed squid.

3) WO (Weaknesses–Opportunities) strategies

a. Improve technological capability through external collaboration

Overcome low technological capacity by partnering with government bodies and external stakeholders to adopt modern tools (e.g., navigation systems, environmental sensors) that improve fishing accuracy and safety.

b. Training and education for fishermen

Address the low education levels among fishers by using external funding to support training programs focused on market literacy, gear handling, and sustainability, thus improving adaptability to changing market and environmental conditions.

4) WT (Weaknesses–Threats) strategies

a. Invest in technology and infrastructure to overcome vulnerabilities

To mitigate both technological limitations and the impact of rising operational costs, prioritize investments in fuel-efficient engines, GPS systems, and cold storage facilities. These measures can enhance resilience and long-term viability under adverse conditions.

Implementation challenges

Despite the well-defined strategies, several barriers may constrain effective implementation:

- Limited Access to Funding: Small-scale fishers often lack the financial capital to invest in modern gear, navigation systems, or training. This continues to be a key obstacle in adopting more efficient and sustainable practices **(Ferrer *et al.*, 2021b)**.
- Gaps in Policy and Governance: Inconsistent or poorly coordinated government support—especially under decentralized coastal governance structures—can lead to delays in accessing subsidies, infrastructure support, and technical assistance **(Kaaji *et al.*, 2024b)**.
- Educational and Technological Readiness: Many fishers come from traditional communities with low formal education levels and limited digital literacy, which inhibits their ability to adopt data-driven tools or new fishing technologies **(Amadu *et al.*, 2021)**.

Strategic recommendations

To address these constraints, a multi-stakeholder approach is essential. Effective implementation will require:

- Government intervention in subsidy provision and infrastructure development
- NGO involvement in capacity-building programs
- Community-based initiatives that bridge education and technology gaps

By aligning strategic priorities with implementation support, squid fisheries at PPSNZ can achieve greater efficiency, resilience, and sustainability.

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CONCLUSION

This study examined the operational and strategic factors influencing squid catch using cast nets at the Nizam Zachman Oceanic Fishery Port (PPSNZ), Jakarta. Between 2019 and 2023, squid production increased significantly; however, variations in catch per unit effort (CPUE) indicated that increased fishing effort did not consistently translate into greater efficiency. These findings suggest that catch outcomes are shaped not only by fishing intensity but also by environmental factors and squid behavioral patterns.

Regression analysis identified key variables with a significant influence on catch performance—most notably, travel distance and fuel consumption. Alongside other operational factors, these variables explained 97.1% of the variation in catch outcomes, emphasizing the importance of efficient resource use, strategic trip planning, and cost management.

Despite positive production trends, several operational challenges remain. These include limited access to navigation tools, low technological readiness, and inequitable access to modern fishing equipment. Addressing these constraints requires targeted strategies such as strengthening external collaboration, enhancing access to modern technologies, and optimizing operational costs to ensure long-term sustainability.

Recommendations for future research

Future studies should:

- Assess the impact of technological upgrades (e.g., GPS, sonar, and digital mapping tools) on navigation efficiency and catch optimization
- Evaluate the feasibility of cooperative fuel subsidy programs, particularly for small-scale fishers operating under tight profit margins
- Explore shared infrastructure models (such as communal cold storage or gear maintenance facilities) that can reduce individual costs and enhance operational efficiency for local fishing communities

These research directions can help bridge the gap between strategic planning and real-world improvements, ultimately contributing to a more resilient and sustainable squid fishing sector at PPSNZ and beyond.

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