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The Effect of Barnacle Stickers (*Balanus* sp) on the Body of Fishing Vessels on the Sailing Speed of Ships at Sea in Sibolga City

Pengaruh Tempelan Teritip (Balanus sp) pada Body Kapal Penangkap Ikan Terhadap Kecepatan Kapal di Laut Kota Sibolga

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Abstract

This research aims to investigate the impact of barnacle attachment (Balanus sp.) on the operational performance of fishing vessels in Sibolga City, focusing on vessel sailing speed and fuel oil consumption. The research used an experimental method with three hull condition treatments: clean hull, hull with moderate coverage (<50%), and hull with severe patch (>50%). Data collected includes speed, distance traveled, cruise time, and fuel usage. Data analysis involved ANOVA (Analysis of Variance) and simple linear regression. The results showed that barnacle patches significantly influenced ship performance (p=0.000). Ships with clean hulls achieved the highest average speed of 7.82 knots, while ships with severe sticking had the lowest speed. Regression analysis (R^2=0.581) confirmed that 58. The level of barnacle attachment caused 1% of the variation in ship speed. Increasing barnacle coverage significantly increases fuel consumption through increasing hydrodynamic drag on the ship's hull. This study concludes that the presence of barnacles substantially reduces the performance and operational efficiency of fishing vessels.

Keywords: Barnacles, Speed, Fuel, Ship

Abstrak

Penelitian ini bertujuan untuk mengkaji dampak menempelnya teritip (*Balanus* sp) terhadap kinerja operasional kapal penangkap ikan di Kota Sibolga, dengan fokus pada kecepatan pelayaran kapal dan konsumsi bahan bakar minyak. Penelitian ini menggunakan metode eksperimental dengan tiga perlakuan kondisi lambung: lambung bersih, lambung dengan penutupan sedang (penutupan kurang dari <50%), dan lambung penutupan parah (>50%). Data yang dikumpulkan meliputi kecepatan, jarak tempuh, waktu pelayaran, dan penggunaan bahan bakar. Analisis data melibatkan ANOVA dan regresi linier sederhana. Hasil menunjukkan bahwa penempelan kerang laut secara signifikan mempengaruhi kinerja kapal (p=0.000). Kapal dengan lambung bersih mencapai kecepatan rata-rata tertinggi sebesar 7,82 knot, sedangkan kapal dengan penempelan parah memiliki kecepatan terendah. Analisis regresi (R^2=0,581) mengonfirmasi bahwa 58,1% variasi kecepatan kapal disebabkan oleh tingkat penempelan kerang laut. Peningkatan tutupan kerang laut secara signifikan meningkatkan konsumsi bahan bakar melalui peningkatan hambatan hidrodinamik pada lambung kapal. Studi ini menyimpulkan bahwa keberadaan kerang laut secara substansial mengurangi kinerja dan efisiensi operasional kapal penangkap ikan.

Kata kunci: Kerang laut, Kecepatan, Bahan bakar, Kapal

1. Introduction

Sibolga City is a center of fishing activity, with many fishing vessels operating in this area. However, one of the challenges faced by fishermen is the operational efficiency of ships, which is greatly influenced by the ship's condition and the marine environment. Research by Harahap et al. (2019) shows that pelagic fishing patterns are strongly influenced by oceanographic conditions, such as currents, temperature, and salinity, which also determine the efficiency of ship operations. Apart from environmental factors, barnacles attached to the ship's hull also have the potential to reduce ship speed while increasing fuel consumption. The attachment of barnacles to ship hulls is often overlooked, even though it significantly impacts ship performance (Putri et al., 2025).

Barnacles are marine organisms that stick to the surface of ships, and their growth can cause various problems. According to research by Deng et al. (2021), Barnacle growth can increase hydrodynamic drag on ships, resulting in reduced speed and fuel efficiency. According to research by Damirel et al. (2017), the attachment of marine organisms can reduce ship speed and increase fuel consumption, thereby affecting operational efficiency. Previous research shows that the attachment of barnacles can cause a reduction in ship speed of up to 20% (Kitade et al., 2024).

This has direct implications for the time and costs required to conduct fishing, which is critical for fishers who depend on operational efficiency to increase their income (Yu et al., 2022). "The Economic Impact of Biofouling on Fishing Vessels." Fisheries Research). Furthermore, research by Grigoropoulus (2022) shows that high barnacle density can have a significant effect on barnacle growth. Cho et al. (2024) emphasized the importance of understanding the interactions between barnacles and substrates for better management. This attachment causes biological contamination, known as biofouling. Regular cleaning of barnacles can be (Romeu et al., 2023). However, this practice is often ignored by fishermen due to a lack of understanding of the negative impacts of barnacles and limited resources to carry out treatment.

Therefore, this research aims to make a positive contribution to the fishing community in Sibolga by increasing the operational efficiency of fishing vessels. This research is not only academically relevant but also has a significant social and economic impact on fishing communities in the area (Siddik et al., 2019). It is hoped that it will provide helpful information for fishermen in vessel management and for other stakeholders in the fishing industry (Wang et al., 2023).

2. Material and Method

2.1. Time and Place

This research was carried out from 23 June to 23 September 2025. The study was conducted in Aek Habil Village, Sibolga City, North Sumatra. The research location is shown in Figure 1.

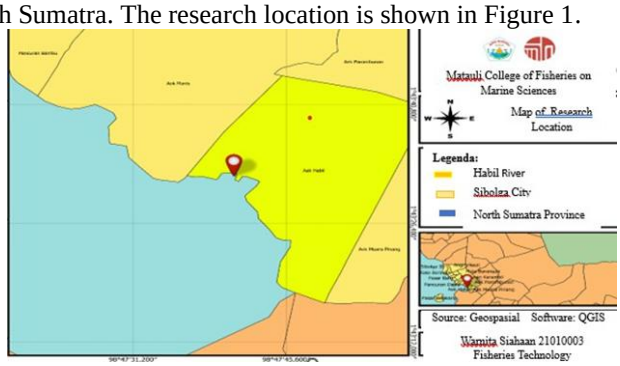

Figure 1. Map of research locations

2.2. Methods

The research uses a quantitative, experimental design. Experimental research is a type of research that involves manipulating an independent variable to observe its effect on a dependent variable. In this study, the independent variable is the level of barnacle attachment, measured using micro quadrants, while the dependent variable is the speed of the ship's sails.

$$\text{Barnacle cover (\%)} = (N_t \div N_g) \times$$

Information:
N_t = small grid covered in barnacles; N_g = total number of grids (400)

2.4. Data Analysis

Speed data from the three ships will be analyzed using descriptive statistical tests to summarize the collected data, and then proceed to the prerequisite Normality and Homogeneity tests. Next, an ANOVA is conducted to compare ship speed across variations in barnacle attachment. If there is a significant difference, a post hoc Tukey test and a regression test will be conducted to assess the magnitude and direction of the effect of barnacle attachment level on vessel speed. Speed Formula (Xu et al., 2022): Speed = Distance / Time

3. Result and Discussion

3.1. Ship Speed Analysis Test

In the descriptive statistical analysis stage, calculations were performed for variables related to ship speed, distance traveled, travel time, and fuel consumption (BBM) for fishing vessels affected by barnacle attachment (*Balanus* sp.). The data used for this analysis consisted of 30 data points per vessel, each tested across 3 barnacle categories (no barnacles, <50% barnacles, and >50% barnacles). Table 1 presents descriptive statistics for the variables analyzed in this study.

Table 1. Descriptive statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Ship Category	30	1	3	2.00	,830
Ship Speed (knots)	30	6.00	8.20	7.1187	,53611
Distance (nautical miles)	30	2.34	4.74	3.5027	,86231
Travel Time (minutes)	30	19	43	29.58	7,310
Fuel (L)	30	4.50	10.00	7.1333	1,78564

Based on the results of descriptive statistical analysis, the average of the ship categories tested was 2.00, which indicates the dominance of ships in the barnacle category <50%. Variations between ship categories are light, with a standard deviation of 0.830, indicating that the majority of ships are in that category. On average, the ship moves at 7.12 knots, with relatively minor variations (standard deviation 0.54 knots), indicating that the ship's speed tends to be uniform. Meanwhile, the average distance traveled by ships was 3.50 nautical miles, with a standard deviation of 0.86 nautical miles, indicating variation during the journey. The average ship travel time is 29.58 minutes, but the variation is greater, with a standard deviation of 7.31 minutes, reflecting differences in travel time between ships. Finally, the average ship fuel consumption was 7.13 L, with greater variation (standard deviation 1.79 L), indicating significant differences in fuel efficiency between ships.

The results in Table 1 show a tendency to decrease ship speed as the level of barnacle attachment to the ship body increases. In other words, the greater the area of the ship's body covered by barnacles, the greater the frictional resistance that occurs between the surface of the ship and seawater, so that the ship's sailing speed decreases. The results of the ANOVA test on the ship speed variable obtained a significance value of 0.000 < 0.05, which means there is a difference in average speed between groups of ships. Because the ANOVA results were significant, a Post Hoc test was conducted to determine group differences.

3.2. Regression Test

This shows that there is a strong relationship between the ship category variable (in this case, influenced by the barnacles attached to the ship's body) and ship speed. The coefficient of determination (R^2) value of 0.581 indicates that. Other factors beyond this research model account for the remaining 41.9%. The Adjusted R Square value of 0.566 strengthens these results, indicating that the regression model is sufficient to explain the relationship between the independent variable (barnacle patch/ship category) and the dependent variable (ship speed). Apart from that, the F test results show a value of 38.798 with a significance level of 0.000 (< 0.05). This indicates that the regression model used in this study is significant and that the ship category (influenced by the barnacle patch) has a real effect on ship speed.

Table 2. Regression test

Model R	R^2	Adjusted R-squared	Std. Error of the Estimate	Change Statistics				
				R Square Change	F Change	df1	df2	Sig. F Change
1,76 2a	,581	,566	,547	,581	38,798	1	28	,000

a. Predictors: (Constant), Ship Speed (knots)

4. Conclusions

This research uses statistical analysis, including ANOVA and Post Hoc Tukey HSD tests, showing significant differences between ships without barnacles, ships with barnacle patches below 50%, and ships with patches above 50%. Vessels without barnacles had the highest sailing speed, whereas vessels with a barnacle patch above 50% showed the most significant decrease in speed as well as an increase in fuel consumption. The linear regression analysis also showed that 58.1% of the variation in ship speed could be explained by barnacle presence, with a fairly strong relationship between barnacle attachment and decreased ship speed. These results strengthen the finding that the more barnacles there are, the lower the ship's performance.

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