

Analysis of the Effectiveness of Ships Berthing with TUG Services at Port Indonesia, Kumai-Bumiharjo Branch, Central Kalimantan

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ABSTRACT

This study aims to analyze the effectiveness of tugboat and ship berthing services at Kumai Port, managed by PT Pelabuhan Indonesia (Persero) Kumai Bumiharjo Branch. The study focused on evaluating the operational performance of tugboats in supporting the ship berthing process, taking into account service time indicators (waiting time and approach time), punctuality, and user satisfaction. The study used a mixed methods approach through quantitative operational data analysis for the period April–June 2025, distribution of questionnaires to service users, and field interviews and observations. The results indicate that the ship berthing process was carried out according to systematic operational procedures, from the time the service request was made until the ship berthed. Ship traffic is dominated by barges and tankers, which have limited maneuverability, resulting in a high dependence on tugboats. In general, the performance of tugboat and berthing services is quite effective, as evidenced by the punctuality of service and minimal waiting time. However, during periods of high traffic, operational effectiveness is still influenced by the limited number and readiness of tugboats, as well as external factors such as river currents and limited maneuvering space. Coordination between operational personnel has been shown to play a significant role in ensuring the smooth and safe berthing process. This study concludes that service effectiveness is determined not only by the adequacy of facilities, but also by operational management, coordination, and human resource competency. Therefore, strengthening fleet capacity, optimizing scheduling systems, and utilizing information technology are strategic steps to improve service performance in the future.

Keywords: tugboat services, ship berthing, operational effectiveness, port management, Kumai Port.

INTRODUCTION

Ports are strategic infrastructure that play a vital role in supporting national economic activities, particularly in facilitating the distribution of goods and passenger mobility. As key nodes in maritime logistics networks, ports must maintain efficient operational systems to ensure smooth vessel movements and cargo handling processes [1]. Efficient port operations depend on the integration of several maritime services, including pilotage, vessel traffic management, and tugboat assistance.

One of the important ports supporting maritime transportation in Central Kalimantan is PT Pelabuhan Indonesia (Persero) Kumai–Bumiharjo Branch. Maritime transportation activities in the province show significant operational intensity. Statistical data indicate that in July 2023 the total number of sea passengers in Central Kalimantan reached 53,870 people, of which 72.62% were served at Kumai Port. In August 2023 the proportion remained high at 70.62%, indicating the dominant role of Kumai Port in regional maritime transportation. In addition, ship traffic activity also fluctuated, with 704 ship calls recorded in March 2023, representing a 13.55% increase compared to the previous month (BPS Central Kalimantan Province, 2023). These figures demonstrate the substantial operational workload handled by Kumai Port, where the reliability of ship berthing processes becomes a critical factor in determining overall port performance.

From an infrastructure perspective, Bumiharjo Port (Kumai), operated by SPMT/Pelindo Multi Terminal, serves general cargo, liquid bulk, and container vessels. The port is equipped with a 392.9 m quay, a 1,560 m² stacking yard, and a 2,616 m² warehouse facility (Pelindo Multi Terminal, 2025). This infrastructure configuration requires careful maneuver planning due to the limited operational space and the diversity of vessel types and cargo characteristics. Safe maneuvering in such conditions often requires assistance from tugboats to ensure vessels can safely approach and leave the berth.

From the regulatory perspective, tugboat assistance in Indonesian waters is governed by Ministerial Regulation PM 57/2015, which specifies the minimum number and bollard pull capacity of tugboats according to vessel length overall (LOA). For example, vessels with LOA 70–150 m require at least one tugboat with a minimum bollard pull of 24 tons, vessels with LOA 150–250 m require at least two tugboats with a minimum bollard pull of 65 tons, while vessels exceeding 250 m require at least three tugboats with a minimum bollard pull of 125 tons (Ministry of Transportation of the Republic of Indonesia, 2015). These regulations serve as the operational baseline to ensure safety and compliance in pilotage and tug-assisted maneuvering activities.

In port operations, tugboats play a critical role in assisting vessels during maneuvering processes such as approaching the berth, turning in limited navigation areas, and controlling ship movement during berthing and unberthing operations. The availability and operational performance of tugboats significantly influence ship turnaround time, navigation safety, and overall port service efficiency [2]. Previous studies have shown that effective tugboat scheduling and coordination can reduce ship waiting time and improve port productivity [3]. In addition, integrated vessel traffic management systems involving pilots, tug operators, and Vessel Traffic Services (VTS) contribute significantly to improving navigation safety and operational coordination within port areas [4].

Despite the importance of tugboat services, operational challenges still occur in many ports, including limitations in tugboat availability, weather disturbances, operational delays, and coordination issues among port service units. These challenges may potentially affect the efficiency and safety of ship berthing operations, and in some cases may increase operational risks and reduce service satisfaction among port users [5]. Therefore, evaluating the effectiveness of tugboat services becomes essential in identifying operational constraints and improving port service performance.

Although several studies have examined tugboat operations in major seaports, research focusing on river and estuary ports, such as Kumai Port, remains limited. River ports have unique operational characteristics, including narrow waterways, tidal currents, and limited maneuvering space, which require different operational approaches compared to large ocean ports [6]. Consequently, an in-depth analysis of tugboat service effectiveness in supporting ship berthing operations at Kumai Port is necessary.

Based on the background described above, this research aims to:

1. Analyze the operational characteristics of ship traffic at Kumai Port.
2. Evaluate the performance of tugboat services in ship berthing operations.
3. Identify operational factors influencing the effectiveness of tugboat services in the port area.

RESEARCH METHODS

Based on the research objectives presented in the Introduction, this study was conducted to analyze the effectiveness of ship berthing operations using tug services at PT Pelabuhan Indonesia (Persero) Kumai Bumiharjo Branch. The research specifically evaluates how tugboat assistance contributes to improving operational efficiency and navigational safety during ship maneuvering and berthing activities within the port area.

This research employed a mixed-method approach, combining quantitative and qualitative techniques using a sequential explanatory design. In this design, the research begins with quantitative data collection and analysis to identify operational patterns, service performance indicators, and ship traffic characteristics. The quantitative findings are then complemented with qualitative analysis through field observations and in-depth interviews to provide a deeper

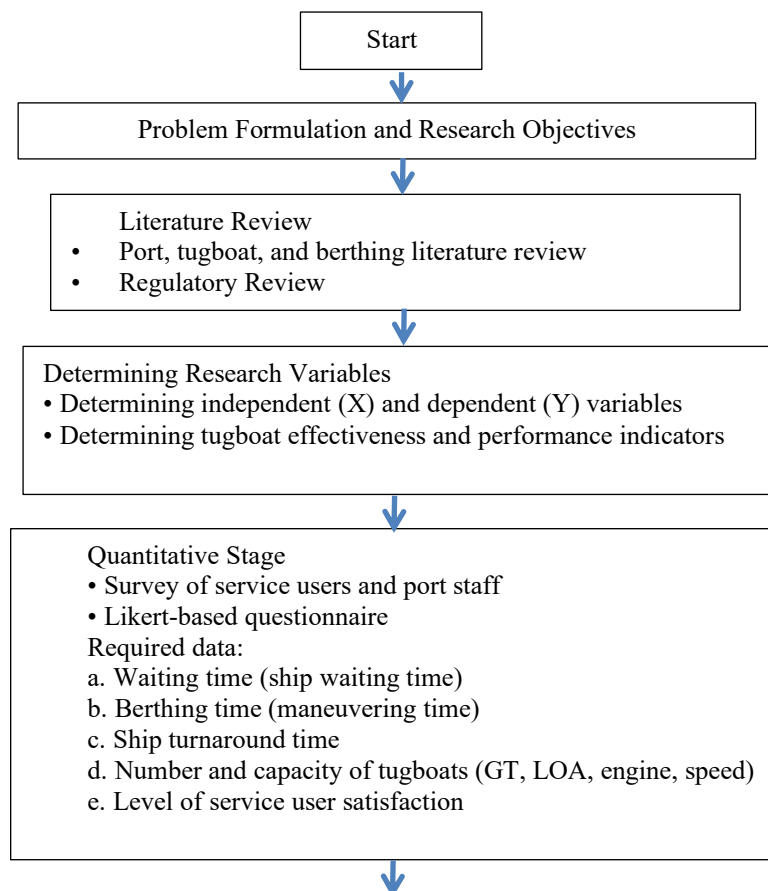
understanding of operational conditions and factors influencing tugboat service effectiveness [6], [7].

The study utilized both primary and secondary data sources. Primary data were obtained through direct field observations and interviews with key informants involved in port operations, including port pilots, tugboat operators, ship agents, and port management personnel. These data were used to capture real operational conditions and stakeholder perspectives regarding ship maneuvering and tugboat services at Kumai Port.

Secondary data were collected through literature studies and document analysis, including port operational reports, statistical records, regulatory documents, and previous academic studies related to port management, ship maneuvering, and tugboat operations. These sources were used to support the theoretical framework and provide contextual understanding of the operational system at the port.

The data analysis process applied inductive qualitative analysis, where conclusions were derived from patterns identified in the collected data. The stages of analysis consisted of data reduction, data display, and conclusion drawing or verification, allowing the researcher to systematically interpret the findings and identify key factors influencing the effectiveness of tugboat services in ship berthing operations [4], [5].

In addition, quantitative data were analyzed descriptively to measure service performance indicators such as waiting time, approach time, and total service time, which are commonly used to evaluate port operational efficiency and service quality [12].



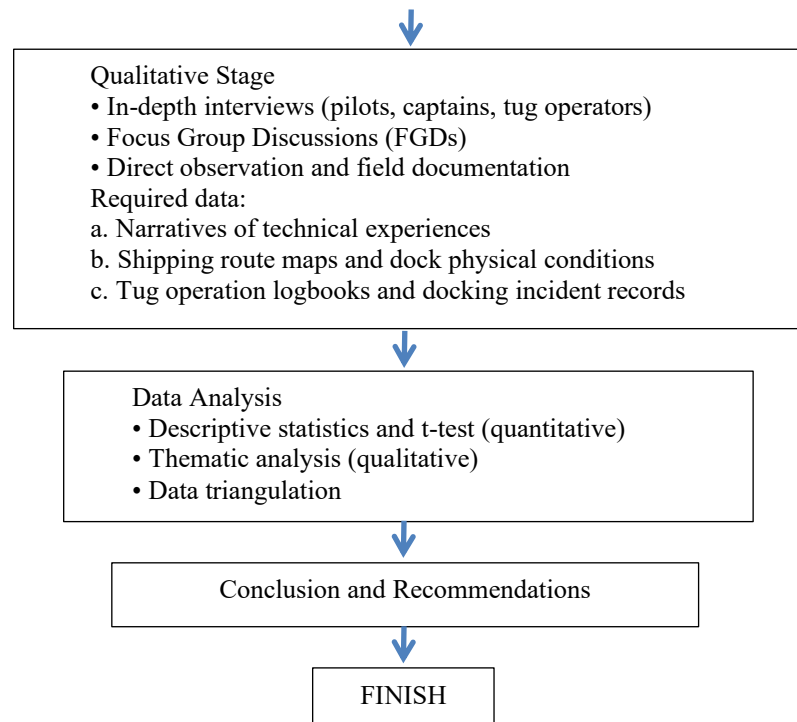


Figure 1. Flow Chart

RESULT AND DISCUSSION

Port Characteristics and Operational Environment

Kumai Port is located in West Kotawaringin Regency, Central Kalimantan Province, and operates as both a river port and an estuary port. The port plays a strategic role in supporting regional logistics distribution, passenger mobility, and the transportation of major regional commodities such as plantation and mining products as well as necessities. Ports located in river and estuary environments generally experience more complex operational conditions compared with open seaports due to hydrodynamic influences such as river currents and tidal fluctuations [8].

From a geographical and hydrographic perspective, the waters around Kumai Port are influenced by river currents, tidal fluctuations, and local weather conditions, which directly affect vessel maneuvering during entry into navigation channels as well as during berthing and unberthing operations. These environmental factors increase the level of maneuvering difficulty and require more precise navigation control and operational coordination [9].

Operationally, Kumai Port serves various types of vessels with different operational characteristics, including general cargo vessels, tankers, barges, and passenger ships. The diversity of vessel sizes, both in terms of Gross Tonnage (GT) and Length Overall (LOA), requires adequate operational facilities and service resources to maintain safety and operational efficiency. In ports with restricted maneuvering areas, tugboat assistance becomes essential for maintaining ship maneuver safety and preventing navigation accidents [10].

Service System and Operational Stakeholders

The tugboat and berthing service process at Kumai Port begins with a service request submitted by the ship agent to the port authority. The request is then scheduled and coordinated by the port management before the vessel enters the port area. During the maneuvering process, the vessel is assisted by a port pilot and supported by tugboat operations to guide the vessel safely to the berth.

This operational system involves several stakeholders, including:

- Port Pilots

- Tugboat Operators
- Vessel Traffic Service (VTS)
- Ship Agents
- Port Authority (KSOP)
- PT Pelabuhan Indonesia (Persero) Kumai Branch

Coordination between these parties is crucial to ensure the smooth implementation of ship maneuvering and berthing operations. Effective coordination among port operational stakeholders has been identified as a key factor in maintaining efficient port services and minimizing operational delays [11].

Ship Traffic Characteristics

Based on operational data collected during the April–June 2025 observation period, a total of 181 ship movements were recorded at Kumai Port. The vessel composition shows that barge vessels dominate the traffic, accounting for approximately 47.5% of the total movements, followed by tanker vessels and Ro-Ro ships.

Table 1. Ship Traffic Distribution by Vessel Type

Vessel Type	Percentage
Barge	47.5%
Tanker	21.0%
Ro-Ro	12.7%
Others	18.8%

The dominance of barge vessels indicates that a large proportion of ships operating at Kumai Port have limited maneuverability, which increases the need for tugboat assistance during berthing operations. Barges typically have lower propulsion capability and reduced maneuvering control compared to self-propelled cargo vessels, making tugboat support essential to maintain navigation safety in restricted waterways [10], which increases the need for tugboat assistance during berthing operations.

Based on vessel size classification, the majority of vessels fall within the 1,000–3,000 GT category (53%), with vessel lengths between 70–100 meters (48.1%). These characteristics show that medium-sized vessels dominate port operations, requiring controlled maneuvering assistance to ensure safe docking.

In terms of operational activities, the most frequent movement is shifting operations, accounting for 35.9% of total movements, followed by incoming and outgoing vessel movements. Peak operational activity generally occurs between 06:01 and 12:00, indicating relatively high operational workload during the morning period.

Service Time Analysis

Service time analysis was conducted using three main operational indicators: waiting time, approach time, and total service time. These indicators are commonly used in port performance evaluations to measure service efficiency and operational effectiveness [12].

Table 2. Waiting Time Distribution

Waiting Time	Ship Movements	Percentage
0 Hours	181	100%
>0–1 Hour	0	0%

Waiting Time	Ship Movements	Percentage
>1 Hour	0	0%

The analysis shows that all ship movements experienced zero waiting time, indicating that tugboat services were immediately available when required. This condition reflects efficient scheduling and coordination between pilots, tugboat operators, and port control units.

Further analysis shows that the approach time for most vessels ranged between 31–60 minutes (45.9%), while the total service time for the majority of operations ranged between 61–120 minutes (56.4%).

Table 3. Distribution of Total Service Time

Service Time	Percentage
≤ 60 Minutes	27.0%
61–120 Minutes	56.4%
>120 Minutes	16.6%

Overall, these service durations fall within a reasonable operational range for river ports, where environmental conditions such as currents and narrow waterways typically require longer maneuvering times compared to open sea ports.

However, approximately 16.6% of services exceeded 120 minutes, which usually occurred due to factors such as larger vessel size, stronger river currents, or limited maneuvering space within the port basin.

Service Punctuality

Operational records also show that 100% of berthing services were carried out on schedule without delays. This result indicates that the port's operational coordination system is functioning effectively, even during periods of relatively high vessel traffic.

Efficient coordination between VTS officers, pilots, and tugboat operators contributes significantly to maintaining service punctuality. Proper scheduling and communication systems are essential for minimizing operational conflicts and ensuring safe vessel movements within port areas [13].

However, maintaining this level of service punctuality depends on the availability and reliability of operational resources, particularly tugboats.

Operational Resource Analysis

Currently, tugboat services at Kumai Port are supported by one operational tugboat unit. Based on operational data, the tugboat handles an average of approximately 60 vessel movements per month, equivalent to around 2–3 maneuvering operations per day.

Under current traffic conditions, this capacity remains sufficient, as indicated by the absence of waiting time for tugboat services. However, reliance on a single tugboat unit presents potential operational risks in cases of:

- increased ship traffic
- technical failures or maintenance downtime
- extreme weather conditions

Although the existing bollard pull capacity is still suitable for the types of vessels currently served, increasing the tugboat fleet could improve operational flexibility and safety margins. Previous studies suggest that adequate tugboat fleet capacity is essential for maintaining efficient port service performance and minimizing operational disruptions [14].

External Operational Factors

Environmental factors such as weather conditions and river currents influence the duration of vessel maneuvering operations. Large vessels and barges are particularly sensitive to tidal currents and water flow conditions, which may require additional maneuvering adjustments during docking operations.

Despite these environmental challenges, the analysis shows that external factors did not significantly affect service punctuality during the study period. The operational system at Kumai Port demonstrates adaptive operational practices that allow services to continue efficiently even under varying environmental conditions.

Furthermore, no significant safety incidents related to ship maneuvering or tugboat assistance were recorded during the observation period.

Service User Satisfaction

The evaluation of service quality also included perceptions from service users, collected through questionnaires distributed to operational stakeholders. Respondents included ship masters, ship agents, pilots, tugboat operators, VTS personnel, and port management representatives.

Most respondents had more than five years of professional experience, indicating that their responses were based on substantial operational knowledge and experience.

The survey results indicate that respondents generally have positive perceptions of the punctuality and coordination of tugboat services. Most service users considered the tugboat and berthing services at Kumai Port to be effective and reliable under current operational conditions.

However, respondents also highlighted the need for continuous improvement in coordination systems and operational readiness, particularly to anticipate potential increases in ship traffic and more complex maneuvering conditions in the future. Continuous service improvement is important to maintain port competitiveness and operational safety [15].

CONCLUSION

This study examined the effectiveness of ship berthing operations supported by tugboat services at PT Pelabuhan Indonesia (Persero) Kumai Bumiharjo Branch, a river–estuary port with complex navigational characteristics. The findings demonstrate that the effectiveness of tugboat-assisted berthing operations is influenced not only by the adequacy of physical facilities but also by operational management, coordination among stakeholders, and the competency of human resources involved in port services. Based on the operational data collected during the April–June 2025 observation period, a total of 181 ship movements were recorded at Kumai Port. The analysis shows that barge vessels dominate traffic (47.5%), followed by tankers (21%), indicating that many vessels operating at the port have limited maneuverability and therefore require intensive tugboat assistance during berthing operations. Most vessels fall within the 1,000–3,000 GT category (53%) and have a length of 70–100 meters (48.1%), which influences maneuvering complexity within the restricted navigation area of the port. From a service performance perspective, the analysis indicates that 100% of vessel movements experienced zero waiting time, reflecting efficient scheduling and coordination among port operational units. The majority of ship maneuvers required 31–60 minutes for approach time (45.9%), while 56.4% of total service operations were completed within 61–120 minutes. These results indicate that the tugboat service system at Kumai Port operates within an effective operational time range for river port environments. The study also identified several operational factors that influence ship berthing performance. These factors include vessel characteristics (LOA and GT), the dominance of vessels with limited maneuverability such as barges, the availability and readiness of tugboat units, coordination among operational personnel (pilots, tugboat operators, Vessel Traffic Service, and mooring teams), and external environmental conditions such as river currents and weather. Among these factors, operational coordination and tugboat readiness play the most significant role in maintaining service efficiency and punctuality. The role of tugboats is therefore crucial in ensuring safe and efficient ship maneuvering, particularly in restricted waterways with strong currents and limited maneuvering space. Tugboats contribute to vessel control during docking operations, reduce the potential risk of navigation incidents, and support the punctuality of port services. Although the current tugboat service performance can be categorized as effective, the

reliance on a single operational tugboat unit may create potential risks if ship traffic increases or technical disruptions occur. Therefore, strengthening operational capacity and improving service coordination are necessary to maintain long-term port service sustainability. From a managerial perspective, the results of this study suggest that port operators need to maintain the current level of service performance by enhancing operational planning, improving inter-unit coordination, and ensuring the availability and reliability of tugboat resources. For port regulators, the findings highlight the importance of policies that support adequate tugboat capacity, strengthen navigation safety standards, and encourage the implementation of integrated operational management systems in river port environments. Overall, this study confirms that the effectiveness of ship berthing operations at Kumai Port is strongly influenced by the integration of technical, operational, and environmental factors. Continuous improvement in tugboat service management and operational coordination will be essential to maintain port efficiency, safety, and service reliability in the future.

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