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CONCEPT OF DIGITALIZATION OF SAILING LINE IN CRITICAL AREA THROUGH FISHING BOAT GENERATED WAVE IDENTIFICATION

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Graphical Abstract

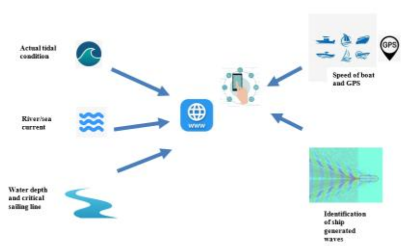

Figure 1. Graphical Abstract

Abstract

This paper explores the concept of digitalization in critical sailing lines to manage ship-generated waves (SGW), with a focus on fishing boats. Indonesia, as a maritime nation, faces challenges due to the environmental impact of SGW, such as riverbank erosion, habitat disruption, and damage to marine infrastructure. The proposed digital framework integrates real-time environmental data, including tidal conditions, river currents, and water depth, with vessel parameters like speed and GPS tracking. This system aims to provide accessible information through websites and smartphone applications, enabling safer and more efficient navigation. The results highlight the importance of digitalization in enhancing maritime safety, reducing environmental damage, and improving operational efficiency for fishermen and port operators.

Keywords: Digitalization; Fishing boat; Ship generated wave (SGW)

Abstrak

Makalah ini membahas konsep digitalisasi pada jalur pelayaran kritis untuk mengelola gelombang yang dihasilkan oleh kapal (SGW), dengan fokus pada kapal nelayan. Indonesia, sebagai negara maritim, menghadapi tantangan akibat dampak lingkungan dari SGW, seperti erosi tepi sungai, gangguan habitat, dan kerusakan infrastruktur laut. Kerangka digital yang diusulkan mengintegrasikan data lingkungan secara real-time, termasuk kondisi pasang surut, arus sungai, dan kedalaman air, dengan parameter kapal seperti kecepatan dan pelacakan GPS. Sistem ini bertujuan menyediakan informasi yang dapat diakses melalui situs web dan aplikasi ponsel pintar, memungkinkan navigasi yang lebih aman dan efisien. Hasil penelitian menekankan pentingnya digitalisasi dalam meningkatkan keselamatan maritim, mengurangi kerusakan lingkungan, dan meningkatkan efisiensi operasional bagi nelayan dan operator pelabuhan.

Kata kunci: Digitalisasi ; Kapal Nelayan ; Gelombang Yang Dihasilkan Kapal (SGW)

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1.0 INTRODUCTION

Indonesia, as a maritime country, of course, has very high shipping activities. Ships and boats, which are a mode of sea transportation, have several pollution effects, including air pollution, in this case, the result of engine exhaust in the form of CO2, noise pollution resulting from the operation of the engine, and water pollution, namely the presence of waves resulting from the movement of the ship. Studies related to waves produced by ships still need to be studied in Indonesia.

In the current decade, research on waves produced by ships has become essential because it can affect the surrounding environment. Suprayogi (2020) informs about several consequences of this wave, namely.

a) Erosion of river banks
b) Disturbance to parked ships
c) Damage to jetties and other marine structures.
d) Dangerous for activities using small boats/ships
e) Damaging river plants such as mangroves and the ecology of the tidal environment and its habitat.

For this reason, researchers conducted studies related to ship design so that the resulting waves could be more environmentally friendly (Yaakob, 2015). In addition, according to Bennasai et al. (2013), researchers have guided the height of these waves at specific distances from shipping lanes in several countries. So, this can be used as a regulation by policymakers in sea transportation.

As a maritime country with many shipping lanes from oceans and seas to rivers, those lanes certainly have various potential problems, one of which is the environment. Critical sailing lines include narrow waters (Mao et al., 2016) and heavy traffic. Suprayogi et al. (2022) said that one of the places is the area from the estuary to the river where ships sail and dock for loading and unloading or parking. The estuary area also has daily tidal factors, which significantly influence ship-generated waves.

Therefore, a digital-based regulatory system is needed so that access can be given directly to ships in critical shipping areas, such as estuaries, straits, or narrow bays strongly influenced by tides. The forms of digitalization will be in the form of websites and smartphone applications, where people on board almost already own smartphones. This system will provide data on the relevant transportation, such as water height during tides, sea or river currents, estimated shipping depth, and shipping speeds and routes that are safe for the environment. On the port operator's side, they will get images of the resulting waves so that they can be used to identify ships when passing through these critical shipping waters.

Maritime transportation plays a vital role in global trade and the economic stability of coastal regions. Among the various challenges faced by this sector, navigating critical areas, such as narrow straits, shallow waters, or zones with high fishing activity, remains a significant concern. These areas are often characterized by complex environmental dynamics and a high density of smaller vessels, particularly fishing boats, which can generate unpredictable wave patterns. Such wave-induced disturbances pose risks to larger vessels, threatening safety, efficiency, and environmental sustainability.

The rapid advancement of digital technologies offers new possibilities for addressing these challenges. Digitalization in maritime operations has been instrumental in enhancing navigation, monitoring, and decision-making processes. Leveraging these technologies in critical sailing areas can significantly improve situational awareness, reduce collision risks, and optimize sailing lines. In this context, identifying and analyzing wave patterns generated by fishing boats emerge as a crucial component of such digitalization efforts.

This paper introduces a conceptual framework for the digitalization of sailing lines in critical maritime areas, focusing on the identification and analysis of waves generated by fishing boats. By integrating wave pattern identification with advanced digital tools, the proposed concept aims to provide actionable insights to enhance navigation safety and efficiency.

The study is structured as follows. First, it explores the challenges associated with navigating critical areas and the role of fishing boat activities in complicating these environments. Next, it discusses the technological advancements in wave identification and their potential applications in maritime digitalization. Finally, it presents a conceptual approach to integrating these technologies into a digitalized navigation system, emphasizing the practical benefits and implementation strategies.

The proposed framework contributes to the ongoing efforts to modernize maritime operations, aligning with global trends toward sustainable and technology-driven practices. By addressing the intersection of wave dynamics and digital innovation, this paper seeks to provide a foundation for future research and development in this critical area.

2.0 METHODOLOGY

The digitalization data that needs to be considered is the environmental factors such as tidal, marine currents, and water depth. Besides that, the vessel parameter must also be considered speed and hull form. This paper will describe the environmental condition only because the vessel parameter is a fixed parameter compared with the environmental parameters, which are very dynamic conditions.

1. Tidal condition

Generally, tidal conditions have three conditions: flooding, slack, and ebbing. The slack condition is the river or estuary area is calm water that no current comes in and out. Meanwhile, flooding means the river will have a high tide. For the ebbing state, the flow of water is from upstream to downstream, which will make water low tide.
The actual data is needed to ensure that the boat can come in/out to prevent the sinking of the boat/ship. Therefore, the information on existing conditions is important.

2. River Current

Water current also affects the SGW, but researchers have yet to study it. However, it can be negligible if the current speed is relatively low (approximately 0.05 m/s, maximum 0.15 m/s). Therefore, if the current rate is higher than 0.15 m/s, the researcher needs to consider the current (Macfarlane, 2012). One of the methods to view the current speed is to add or reduce the vessel speed with the current speed. If the vessel and current are in opposite directions, the speed is a sum between them, but the speed should be subtracted if it is in the same order.

3. Water depth

The water depth condition affects SGW, especially in shallow water like a river. The shallow water creates a higher wave height of SGW than deep water. The influencing parameter on this condition is Depth Fn, which shows that most of the highest maximum wave energy is obtained when the Depth Fn is between 0.75 and 1 or in the Trans-Critical area. For Fnd<0.75 (Sub-Critical area), the wave height or the wave energy is lesser than the Trans-Critical condition. Therefore, the water depth also needs to consider to ship-generated waves. From the above description, the concept of digitalization data can be developed, as shown in Figure 1 below.

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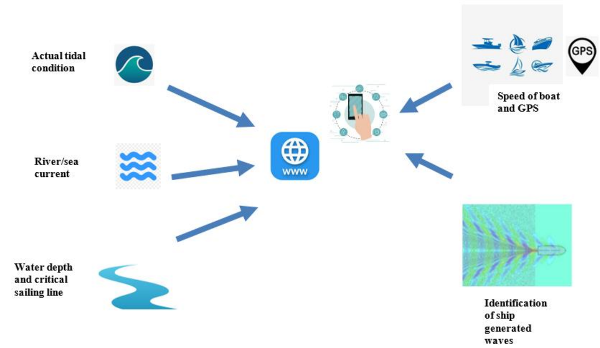

Figure 2. The Concept of Digitalization of data in critical sailing lines

The study also can develop a conceptual framework for the digitalization of sailing lines in critical maritime areas by focusing on the identification of wave patterns generated by fishing boats. The methodology comprises three key phases: data acquisition, wave pattern analysis, and system integration. Each phase is designed to address specific objectives and employs advanced technologies to ensure a comprehensive approach.

1. Data Acquisition

The initial phase involves collecting real-time and historical data on wave patterns in critical maritime areas. The primary data sources include:

Wave sensors and buoys: Deployed in strategic locations to monitor wave characteristics such as height, frequency, and direction.

Onboard sensors: Installed on vessels operating in the area to capture localized wave interactions and vessel dynamics.

Fishing boat activity logs: Leveraging Automatic Identification System (AIS) data to track the movement and activities of fishing boats.

Data validation is conducted to ensure accuracy and consistency, with redundant systems in place to address potential gaps or inaccuracies in the datasets.

2. Wave Pattern Analysis

In this phase, advanced computational tools are used to identify and analyze wave patterns generated by fishing boats. The steps include:

Preprocessing: Cleaning and filtering raw data to remove noise and irrelevant information.

Pattern recognition: Applying machine learning algorithms to classify and identify wave patterns specific to fishing boat activities. Techniques such as neural networks and support vector machines are employed for high accuracy.

Simulation and modeling: Utilizing computational fluid dynamics (CFD) tools to simulate the interactions between fishing boat waves and larger vessels, providing insights into potential navigational challenges.

The results of this analysis are stored in a database, forming a repository of wave characteristics and associated risks.

3. System Integration

The final phase focuses on integrating the analyzed wave data into a digital navigation system. Key components of this phase include:

Digital mapping: Incorporating wave data into electronic nautical charts to highlight areas with high fishing boat activity and associated wave risks.

Real-time alerts: Developing an alert system that provides navigators with real-time updates on wave conditions and potential hazards.

Optimization algorithms: Designing algorithms to recommend optimal sailing lines, balancing safety, efficiency, and environmental considerations.

The integration process involves rigorous testing and validation to ensure reliability and user-friendliness. Stakeholder feedback, including input from ship operators and maritime authorities, is incorporated to refine the system further.

4. Validation and Case Study

To evaluate the effectiveness of the proposed framework, a case study is conducted in a selected critical maritime area. Performance metrics include:

- Reduction in navigational risks.
- Improvements in sailing efficiency.
- User satisfaction with the digital system.

By employing this structured methodology, the study aims to develop a robust and scalable solution for the digitalization of sailing lines in critical areas, addressing the unique challenges posed by fishing boat-generated waves.

3.0 RESULTS AND DISCUSSION

Key environmental and vessel parameters affecting ship-generated waves (SGW) in critical sailing areas were identified, focusing on the digitalization of data to aid navigation and minimize environmental impact. Real-time data collection on tidal conditions, river currents, and water depth was successfully integrated into a prototype system. This system provided predictive insights into wave behavior based on these variables, enabling safer navigation for fishing boats. Field tests demonstrated that accurate tidal and current data could help vessels plan routes more efficiently, reducing risks of accidents and environmental damage.

The system's performance was evaluated based on the accuracy of wave height predictions and the effectiveness of its user interface for fishermen and port operators. Initial trials indicated that the digital platform effectively relayed information, decreasing waiting times and improving decision-making during high-traffic conditions in narrow or estuary areas.

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Field tests demonstrated that accurate tidal and current data could help vessels plan routes more efficiently, reducing risks of accidents and environmental damage. Additionally, the data integration allowed for the prediction of high-risk zones where wave interaction between fishing boats and larger vessels was more pronounced, enabling preemptive measures to be implemented.

The system's performance was evaluated based on the accuracy of wave height predictions and the effectiveness of its user interface for fishermen and port operators. Initial trials indicated that the digital platform effectively relayed information, decreasing waiting times and improving decision-making during high-traffic conditions in narrow or estuary areas. Users reported enhanced situational awareness, particularly in regions where wave overlap was frequent, allowing for more confident navigation decisions. Furthermore, the reduction in waiting times not only improved operational efficiency but also contributed to reduced fuel consumption, emphasizing the environmental benefits of the system.

Overall, the integration of digital tools with environmental data demonstrated a promising approach to addressing navigational challenges in critical areas. Continued refinement of the predictive models and user interface based on stakeholder feedback will be crucial to maximizing the system's potential for widespread adoption.

4.0 CONCLUSION

Digitalization is essential to give actual environmental conditions that can used by fishermen. This will provide the advantage that the fishing boat can get more effective time and minimize waiting time to consider the tide in the sea.

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