Managing Biofouling from Ships in Indonesia: Regulation versus Implementation

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Abstract. The IMO Glofouling project, which was launched at the end of 2018, ended in early 2025. Indonesia, as one of the leads partnering countries (LPC), has responsibilities to implement the IMO guidelines in biofouling management. The present paper reviews the resolution MEPC.378 (80) together with the Indonesian Government Regulation as guidelines for the control and management of ships' biofouling to minimize the transfer of invasive aquatic species. Surveys are carried out in 4 major shipyards in Surabaya (2), Jakarta (1), and Balikpapan (1) as well as at the BKI Headquarters in Jakarta which responsible on ships checking maintenance and renew the classification of repaired ships. Investigation into traditional fisher communities is also included to comprehend their awareness about the very serious issue of biofouling attacks on their livelihoods. Based on the survey questionnaire, the discussions include the technical aspects of handling biofouling (such approaches and technologies used), social aspects (to cover the knowledge and understanding of the communities on such regulations), and economic aspects (e.g., spending cost on regular bottom cleaning). Finally, the appropriate method or solution is provided.

1 Introduction

Climate change has become one of the most critical challenges facing humanity, influencing almost every aspect of Biofouling is known as aquatic organism including microfouling such as bacteria, diatoms, and fungi, and macrofouling such as barnacles, mussels, and seaweeds [1]. Both microfouling and macrofouling can cause significant structural and economic damage, especially to ships and underwater equipment. In connection with ships and shipping, biofouling is well known as one of the main problems in the maritime sector due to its effect to increase the roughness of the ship hull [2]. Subsequently, this will increase frictional resistance and hence the fuel consumption and emission of toxic gas into the atmosphere.

In terms of environmental issues, biofouling can be invasive hence triggers foremost jeopardize to the sea and the conservation of biodiversity. Serious protection should be taken into consideration such as carried out by the Australian and New Zealand Governments; the two countries require every foreign vessel to have certificate of clean from biofouling before entering Australian and New Zealand waters [3]. Utama et al. [4] discussed the risk of Indonesia from biofouling attack because of being archipelagic country. The geographic position of Indonesia between two continents (Asia and Australia) and between two oceans (Pacific and Indian Oceans) has made Indonesia to be an open country for shipping worldwide. The potencies of danger may come from foreign flag fishing vessels, international recreational craft, offshore oil gas activities, domestic shipping, etc.

In terms of economy, biofouling strike has caused global economic loss up to 0.25% GDP in developed countries. According to OECD [5] Indonesia has to spend about 5.2 million USD annually to handle biofouling effect when there is no policy or regulation, whilst it becomes 2.6 million USD (or 50% reduction) when a proper policy is implemented. There is no clear policy before on handling biofouling waste from shipyards. The biofouling from a ship is washed away to the water without worrying about the risk of the life biofouling becomes invasive. By the regulation, the biofouling debris must be collected and treated further and cannot be dumped to water directly. So far, Indonesian Government has released regulation on antifouling control, ship hull, and tank cleaning under Ministry of Transportation Regulation Number 29/2014 [6]. Details of strategy to anticipate the attack of biofouling is not available, thus Indonesia follows the International Maritime Organization (IMO) guidelines with continuous efforts on strategy development under IMO Glofouling Project [7].

In order to understand in more details, the strategy and implementation of biofouling management in Indonesia, the current paper reviews the resolution MEPC.378 (80) [8] together with the Indonesian Government

Regulation as guidelines for the control and management of ships' biofouling to minimize its effects on Indonesian economy. Survey questionnaires are made and the participants include related parties in the maritime fields such as shipyards and classification societies.

2 Method

This study adopts a mixed-method approach that integrates literature review, data collection through regulatory analysis and field surveys, and targeted investigations across key maritime sectors in Indonesia. The overall objective is to evaluate the alignment between the regulatory framework for biofouling management and its actual implementation within shipyards, classification societies, and coastal communities.

First, a comprehensive literature review was undertaken to examine international and national regulatory instruments governing biofouling management. Core documents include IMO Resolution MEPC.378(80) [8] as the global guideline, complemented by relevant Indonesian government regulations that operationalize biofouling control and the prevention of invasive aquatic species. Academic publications, technical guidelines, and policy reports related to biofouling management practices, antifouling technologies, and invasive species pathways were also reviewed to establish a theoretical and regulatory foundation for the study.

Second, systematic data collection was conducted through two primary channels:

1. Survey-based data collection, which employed structured questionnaires distributed to shipyards, regulatory bodies, and classification societies. The survey aimed to capture stakeholders' understanding of biofouling management, their degree of compliance with IMO guidelines, and the technological or operational challenges encountered in practical implementation. Survey responses were analyzed to identify patterns of compliance, awareness levels, and gaps between regulatory expectations and industrial practices.
2. Regulatory data collection, involving the examination of national regulations, ministerial decrees, and technical standards that dictate the obligations of ship operators, shipyards, and inspection bodies in Indonesia.

Third, investigations were extended to traditional fishing communities to assess their awareness of biofouling and the extent to which fouling organisms affect the performance, safety, and economic sustainability of small fishing vessels. Surveys in some fisheries communities such as in Brondong (East Java) and Pengambengan (Bali) indicated that the fishermen do not really understand how to cope with biofouling on their fishing vessels. They just cleaned the surface and repainted it without checking if the biofouling has infiltrated inside the wooden boat hence can break the boat later. Consequently, this affected the safety of the boat and reduce its performance at sea. These investigations combined semi-structured interviews and observational assessments to document the experiences of fishers with hull fouling, their existing cleaning practices, and their knowledge of regulations associated with biofouling management.

The triangulation of these three methodological components allows the study to establish a holistic understanding of biofouling management in Indonesia. The literature review provides the regulatory and conceptual baseline; the survey data from shipyards and regulatory institutions quantify the level of implementation; and the community-level investigations offer insights into socio-economic impacts and local awareness. Combined, these methods, supported by thematic (qualitative) analysis of interviews, enable a rigorous assessment of the extent to which national implementation aligns with IMO's global framework and where gaps remain between regulation and practice.

3 Result and Discussions

3.1 The IMO Regulation (MEPC.378 (80)

IMO released MEPC.378 (80) adopted on 7 July 2023 as the guidelines for the control and management of ship's biofouling to minimize the transfer of invasive aquatic species (IAS). Continues studies by IMO members have identified the invasive aquatic species as one of the major threats for the well-being in the ocean. The guidelines have the intention to reduce the enlargement of biofouling growth on ships. Biofouling management practices may also improve a ship's hydrodynamic performance and can be effective at enhancing energy efficiency and reducing emission of toxic gases to the atmosphere from ships.

Fig. 1. Biofouling attack on ship hull: (a) barnacle dominated, and (b) barnacles, calcareous deposit, and soft fouling on ship's rudder

In the case of Indonesia, the Indonesian government determine outline for preventing the spreading of IAS and biofouling management in accordance with IMO regulations by national regulations, namely Minister of Transportation regulation on PM 29/2014. According to the regulation, an assessment and survey must be carried out to all ships of more than 400 GT or 24 m length operated in Indonesian waters; anti-fouling management and control are taken into consideration. An example of biofouling attack on a ship in Indonesia is shown in Figure 1. It is apparent that the biofouling (barnacles) attacks the surface of ship hull (Figure 1a) and barnacles combine with calcareous deposit and soft fouling attack ship's rudder.

The cleaning of biofouling can be carried out on land, e.g., using dry dock, and under water activities using professional divers together with appropriate tools as well as using robots of remotely controlled underwater vehicles. Furthermore, the debris must be treated properly and cannot be splashed out by water to dump the biofouling into the sea; collecting the debris with further treatment is recommended. Figure 2 shows the cleaning process of biofouling debris in a shipyard.

Fig. 2. Biofouling debris

3.2 Survey Investigation

In order to understand if the biofouling debris has been treated according to the regulation a series of surveys were carried out at shipyards in Balikpapan and Surabaya, together with special visit and survey to BKI (Indonesian Classification) which has the authority, see Figure 3. The survey findings are presented in Table 1.

PT. Galangan Balikpapan Utama

PT. Adiluhung Sarana Segara Indonesia

PT. Dumas Tanjung Perak Surabaya Shipyard

PT. Biro Klasifikasi Indonesia

Fig. 3. Survey Activities Documentations

Table 1 presents a structured assessment of biofouling-related practices and regulatory conditions within Indonesian shipyards and classification societies, examined through technical, social, and economic dimensions. Collectively, these dimensions illustrate both the strengths and the systemic gaps that influence the overall effectiveness of biofouling management in the national maritime sector.

PT. Galangan Balikpapan Utama engages in meticulous hands-on inspections and supervision, focusing primarily on critical aspects such as hull integrity, the application of antifouling coatings, and the overall operations conducted within drydock facilities. This comprehensive approach ensures that every vessel undergoes thorough evaluations to maintain structural soundness and performance efficiency. The team employs advanced techniques and industry best practices to assess the condition of the hull, ensuring that any potential issues are identified and addressed promptly. Additionally, the careful application of antifouling materials is executed to enhance the longevity and operational efficiency of the vessels, preventing marine growth that can adversely affect performance. The drydock operations are meticulously managed to provide a safe and efficient environment for maintenance and repairs, reflecting the company's commitment to quality and excellence in maritime services.

PT. Adiluhung Sarana Segara Indonesia ensure adherence to various regulatory frameworks, such as the Minister of Transportation Regulation No. 29/2014, which pertains to antifouling measures and the cleaning of tanks. This compliance process could involve close collaboration with the Indonesian Classification Bureau (BKI) as well as the Ministry of Transportation to ensure that all operational practices meet the established safety and environmental standards. Engaging with these regulatory bodies is crucial for maintaining the integrity of maritime operations and ensuring that the company aligns with national policies aimed at promoting sustainable practices within the shipping industry.

PT. Dumas Tanjung Perak Surabaya Shipyard is intricately involved in the execution of antifouling systems, which are essential for maintaining the integrity and performance of marine vessels. The shipyard prioritizes hull maintenance to ensure that ships operate efficiently and safely, minimizing the risk of damage and enhancing their longevity. Additionally, the facility adheres to stringent pollution control procedures, reflecting its commitment to environmental stewardship and compliance with maritime regulations. By integrating these critical practices, PT. Dumas Tanjung Perak Surabaya Shipyard not only supports the operational needs of its clients but also contributes to the broader goal of sustainable shipping practices.

PT. Biro Klasifikasi Indonesia (BKI) serves as the national classification society tasked with ensuring adherence to various regulatory frameworks, including the Minister of Transportation Regulation No. 29 of 2014. This regulation specifically addresses standards related to the cleaning of hulls and tanks, which are critical for maintaining maritime safety and environmental protection. BKI's role involves rigorous verification processes to confirm that vessels comply with these established standards, thereby promoting best practices within the shipping industry and safeguarding marine ecosystems from potential pollutants. Through its oversight, BKI contributes significantly to the enhancement of maritime operations in Indonesia, ensuring that they align with both national and international safety and environmental regulations.

From a technical perspective, shipyards in Indonesia predominantly conduct hull-cleaning activities on repair vessels, while new-build facilities seldom undertake such procedures. This distinction suggests the existence of different operational priorities between maintenance-focused and production-oriented shipyards. The documented reliance on sandblasting, as well as the drying and mixing of biofouling residues, underscores the continued dependence on traditional surface-preparation techniques. The mention of licensed waste-management vendors and containment measures indicates an emerging awareness of environmental stewardship; however, the absence of detailed procedural standards suggests room for greater harmonization and regulatory enforcement. Ensuring consistent environmental controls is particularly important given the increasing international focus on hull fouling as a vector for invasive aquatic species.

The social aspects highlight a workforce that is generally trained for specialized cleaning operations, especially in sandblasting. The provision of standard personal protective equipment (PPE) reflects baseline compliance with

occupational safety norms, though the availability of supplementary protective gear in some shipyards reveals variability in safety culture across facilities. Reports of minimal community impacts, with occasional odors noted in industrial zones, imply that current practices do not pose significant perceived social burdens. Nevertheless, this may reflect limited monitoring or underreporting rather than actual environmental neutrality. Comprehensive community-level assessments would help validate the extent of social acceptability and identify any latent concerns.

Economically, the cost structure of hull cleaning displays wide variability, ranging from relatively minor expenses during underwater or basic repair activities (0.5–5%) to substantially greater costs when painting and sandblasting are included (up to 45–50%). This spread indicates that hull-cleaning expenditures are highly sensitive to the scope and intensity of surface-renewal procedures. The behaviour of shipowners further contributes to this variability: some prefer frequent cleaning cycles without investing in antifouling paints, while passenger vessels typically adopt routine repainting. Such differences highlight the absence of a unified economic strategy for hull maintenance within the industry. Notably, the lack of community complaints regarding biofouling waste suggests either effective waste handling or limited public engagement with maritime environmental issues. Systematic socioeconomic impact assessments would be beneficial in validating these observations.

Finally, the section on classification societies underscores Indonesia's regulatory posture. Although the country has ratified international antifouling regulations through Perpres 66/2014, the corresponding national regulation on biofouling management remains under development. The involvement of BKI in a joint task force with the Ministry of Transportation reflects a proactive institutional approach toward aligning national frameworks with IMO MEPC.378(80). However, the ongoing drafting process highlights an existing regulatory void that may hinder uniform implementation across shipyards. Strengthening these frameworks is essential to ensure compliance, environmental protection, and alignment with global best practices.

Table. 1. Results of data collection

Category	Aspect	Description
Shipyard	Technical	- Hull cleaning is conducted on most repair vessels, while new-build yards rarely engage in such practices. - Waste management generally involves drying/mixing biofouling with sandblasting residues or disposal via licensed vendors. - Procedures ensure containment and prevent contamination of surrounding waters.
	Social	- Workers receive specialized training, primarily in blasting, and are equipped with standard PPE; some shipyards provide additional protective gear. - Community impacts are minimal, with occasional odor reports in industrial areas.
	Economic	- Hull cleaning costs range from 0.5–5% of repair/underwater work and may reach 45–50% when painting or sandblasting is included. - Shipowners either invest in antifouling coatings or prefer more frequent cleaning; passenger vessels typically undergo annual repainting. - No community complaints related to biofouling waste have been recorded.
Classification Society	-	Indonesia has ratified international antifouling regulations (Perpres 66/2014), but national rules on biofouling and IAS management aligned with IMO MEPC.378(80) are still being drafted. BKI is part of a joint task force with the Ministry of Transportation to develop these regulatory strategies.

Although Indonesia has ratified international antifouling regulations through Perpres 66/2014, the absence of a finalized national regulation on biofouling management presents a significant gap in the regulatory framework. This gap may lead to the inconsistent application of antifouling measures across different shipyards, potentially undermining efforts to control the spread of invasive aquatic species and protect marine ecosystems. Therefore, the development of comprehensive national biofouling management regulations is critical to ensure that international standards, such as those outlined in IMO MEPC.378(80), are effectively translated into enforceable domestic policies.

The involvement of the BKI in a joint task force alongside the Ministry of Transportation demonstrates a strategic and collaborative approach to addressing this regulatory shortfall. By aligning national policies with international mandates, the task force aims to establish uniform biofouling management practices that facilitate compliance. However, the ongoing drafting process underscores the complexity of integrating international guidelines into the national legal system, which requires coordination among multiple stakeholders and careful consideration of local maritime industry conditions. Until this process is complete, the regulatory void may pose challenges to consistent implementation and monitoring, highlighting the need for accelerated policy development and stakeholder involvement.

4 Conclusions

This study investigates the coherence between international and national regulations on biofouling management in Indonesia and their practical application in the maritime sector. Utilising a mixed-methods approach, this study integrates a comprehensive literature review, surveys conducted among shipyards and classification societies, and field investigations within traditional fishing communities. A critical analysis of the International Maritime Organization's MEPC.378(80) guidelines in conjunction with Indonesian regulations was undertaken. The survey

findings indicate that shipyards predominantly engage in hull-cleaning activities for repair vessels, employing techniques such as sandblasting and various waste management practices, which exhibit inconsistent environmental controls. Although training programs for the workforce and safety protocols are in place, the economic implications of hull cleaning show significant variability across different operations. Further socialization and education should be given to fisheries communities due to their high numbers in population and the majority of them are very poor; the do not have adequate money to maintain their boats ad well as handling the biofouling and its effects.

Despite Indonesia's ratification of international antifouling regulations, the corresponding national legislation is still in the developmental phase, raising concerns about potential discrepancies in implementation. This study underscores the urgent need to establish comprehensive national regulations governing biofouling management and enhance regulatory frameworks to ensure alignment with global best practices. By addressing these gaps, Indonesia can better facilitate compliance and promote sustainable practices within its maritime industry, ultimately contributing to the protection of marine ecosystems and enhancing the sector's economic viability.

Acknowledgement

The research is funded under a research scheme called "ITS Centre Collaboration Research" Batch 1/2025 with contract number: 1952/PKS/ITS/2025.

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